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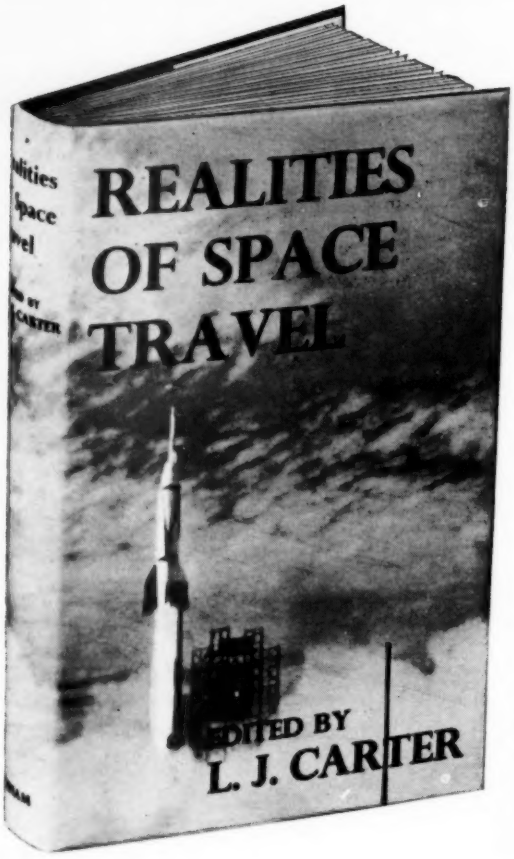

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The British Interplanetary Society was founded in 1933 to promote the development of interplanetary exploration and communication by the study of rocket engineering, astronomy and other associated sciences. It now includes among its members many British and foreign workers prominent in these fields.

The Society organizes meetings, lectures, exhibitions and film shows. These programmes are planned not only to assist the spread of technical knowledge, but to stress the limitless possibilities of rocket propulsion, and in particular the ultimate implications to human society of the crossing of space.

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Editorial

Up to now, it has been our policy to present articles covering a wide range of topics. It seems that this has met with general approval, and No. 3 of *Spaceflight* follows closely on the lines of its predecessors.

In the past, much has been heard of the meteor hazard; it has even been stated that any craft which is incautious enough to leave the shelter of the atmosphere will at once be battered to pieces by a kind of cosmic shell-fire. We are therefore very glad to include a long article by Dr. N. H. Langton, a well-known authority in this field, dealing with all aspects of meteoric astronomy and putting the hazard in its proper perspective.

In our last issue, W. H. Haas, one of the organizers of "Project Moonwatch", described the programme to be undertaken; in the present number he has sent a note about the postponement of the U.S. national "alert". G. V. E. Thompson, who needs no introduction to any of our readers, has continued his historical series by describing the life and work of that important but somewhat erratic German pioneer Hermann Ganswindt; A. V. Cleaver has said something about Woomera, the Australian rocket range which is sometimes forgotten by non-technicians owing to the greater prominence of White Sands. The "Sky Diary", which appears to have been a popular feature, has been written on this occasion by G. Turner, who is best known for his observational work in connection with the Moon. Dr. A. E. Slater's article on "Weightlessness" deals with another vital astronautical problem; in No. 4 of *Spaceflight* we shall be continuing this discussion with a description of problems of acceleration, written by Flight-Lieutenant M. K. Browne of the Royal Aircraft Establishment at Farnborough.

In lighter vein, we have cartoons from S. W. Greenwood, D. A. Hardy and R. F. Chapman; also an article by W. Johnson, who formerly carried out engineering work in Newcastle but who has now left this country for the United States.

Mars has now receded once more after its close approach last year, and the preliminary results of work at Mount Wilson are summarized by Dr. R. S. Richardson. Dr. Richardson, who is—we are glad to say—a member of the British Interplanetary Society, is of course very well-known to everybody in the astronomical world, and is moreover the author of a number of popular books, including *Sun, Moon and Stars* and *A Brief Text in Astronomy* (both with W. T. Skilling) and *Man and the Planets* (published in America under the title of *Exploring Mars*).

It will be noted that we have started a Correspondence Column, and letters for publication, as well as articles, will be welcomed for consideration by the Editorial Board. Meanwhile, it is hoped that No. 3 of our periodical will meet with your approval.

PATRICK MOORE,
Editor.

Postponement of the "Moonwatch" Alert

By W. H. HAAS

In No. 2 of Spaceflight, *W. H. Haas, one of the organizers of the "Moonwatch" visual satellite tracking programme, outlined the principles of the project. The programme was originally meant to start in late* 1956, *but has now been postponed for the reasons given by Haas in the following message.*

The postponement of the United States National Moonwatch Alert, originally scheduled for early December, 1956, was intended to give additional amateur groups more time to organize, so that they would be better able to participate in the Alert. One would have to do very well to assemble the necessary optical equipment in only a few months. Finance has also been a major problem for many societies; a fully-equipped station costs from £150 to £300. In some American cities, large companies or banks have underwritten local "Moonwatch" stations, sometimes as an advertising project.

"Moonwatch" will perhaps be most useful if it is set up to recover the satellite as soon as possible after launching; that is to say, the visual programme as a whole will be most needed if the optical and radio instrumentations fail. The orbit of the satellite may then be completely uncertain, and we can only be sure that the inclination of the orbit to the equator will not be less than the latitude of the launching site in Florida. Thus, stations near the southern edge of the United States are sure of being able to see the satellite, and have an additional responsibility for attempting to do so. No such guarantee can be given for observers in England.

Meteors and Spaceflight

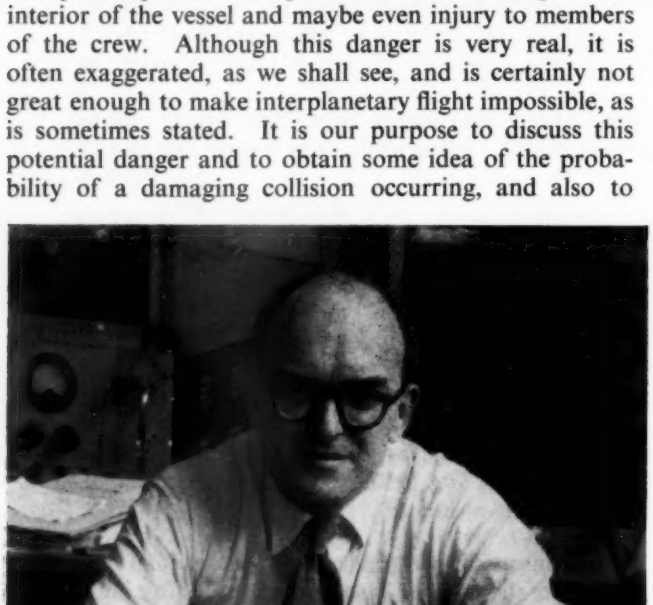
By N. H. LANGTON, M.SC., PH.D., A.M.BRIT.I.R.E., A.INST.P.

Much has been heard of the meteor hazard in spaceflight. This article surveys the whole field of meteoric astronomy.

Introduction.

Every hour of every day, thousands of intruders from interplanetary space enter the atmosphere of the Earth. Only the largest, and these are very few in number, ever manage to penetrate the atmosphere and reach the surface of the Earth. This sounds rather like the beginning of a science fiction story, but, when we say that these intruders are meteorites, we shall see that this statement is perfectly true.

We are interested in meteorites from the point of view of interplanetary flight because their presence in space forms one of the most obvious potential hazards to a vessel leaving the protection of the Earth's atmosphere. The danger lies in the possibility of collisions between the rocket ship and the meteor particles, both of which would be travelling at high speeds. Such a high speed collision might involve the penetration of the hull of the spaceship with subsequent loss of air, damage to the interior of the vessel and maybe even injury to members of the crew. Although this danger is very real, it is often exaggerated, as we shall see, and is certainly not great enough to make interplanetary flight impossible, as is sometimes stated. It is our purpose to discuss this potential danger and to obtain some idea of the probability of a damaging collision occurring, and also to describe a method of protecting the rocket ship or artificial satellite against such collisions. To appreciate more fully the danger, we must first consider the nature of meteor particles and the speeds and numbers of them near the Earth.



Dr. N. H. Langton

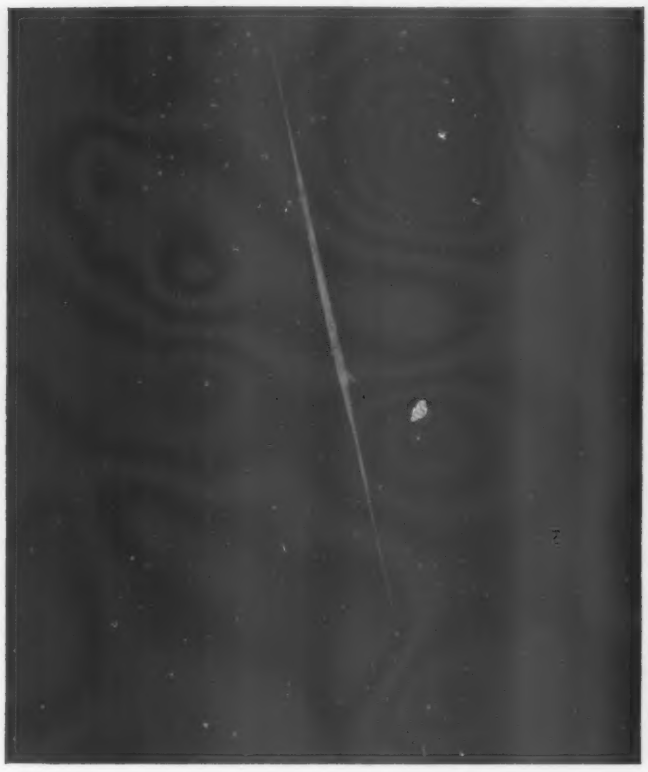
Falling Stars.

In the year 1833 a large number of people in this country, amongst others, were convinced that the world was about to end. On the night of November 11 the sky was filled with brilliant falling stars; over 20,000 fell each hour for most of the night. We now know that this phenomenon was due to a swarm of meteors called the Leonids. It is this phenomenon of "falling" or "shooting" stars which first acquaints most of us with meteors, although their cause was not known until the last century. There are records of falling stars going back about 2,600 years, but even before this time, no doubt, mankind was familiar with the sight. It is thought that prehistoric man obtained some of his iron from fallen particles picked up on the Earth's surface, and no doubt regarded this as a gift from the gods in the skies.

Falling stars were usually regarded with superstitious dread. In many parts of the world meteors were worshipped and built into walls of temples as sacred stones. In fact the word "meteor" comes from the ancient Greeks and means "things in the air". The Chinese catalogued falling stars in 616 B.C., whilst Livy mentioned a shower of stones falling on Mount Alban, near Rome, in about A.D. 654. The ancients thought that falling stars were generated in the atmosphere, as the word meteor implies, and the ancient Greeks regarded them as projectiles pelted at erring humanity by irritated gods, although the number of direct hits obtained speaks very poorly of their accuracy. It was not until the great shower of 1833 that scientists became convinced that the origin of meteors was outside the atmosphere, and only recently was it realized that they nearly all come from within the Solar System and not from outer space. In fact, it was as late as 1803 that the work of the French physicist, Biot, convinced scientists that bodies falling from the sky really did exist, and were not a figment of popular imagination. Nowadays millions of these bodies have been observed and tracked both visually and by radio astronomy.

Meteorites.

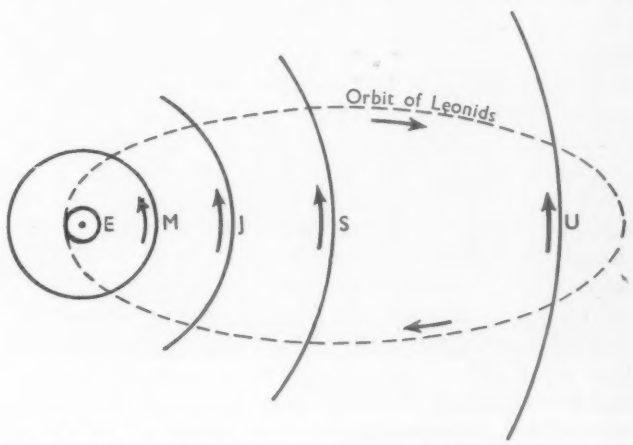
The name meteor refers to the atmospheric effects we see, whilst the particles causing these effects are called



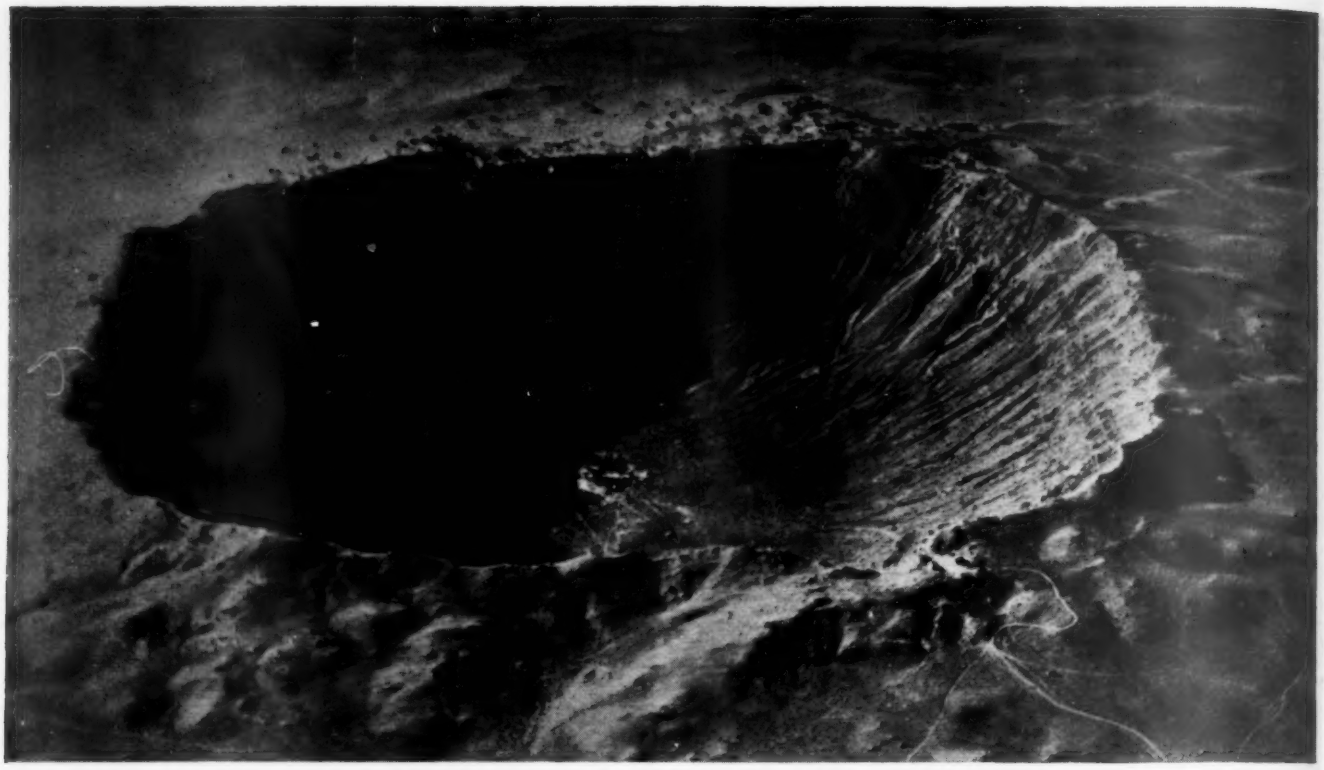
(*Left*) Meteor Trail and Comet Brooks, 13/11/43. Barnard

(*Right*) Photograph of a meteor in flight. (*Published by permission of Hutchinson's, London. Reproduced by L. Moulder*)

meteorites. Associated with meteorites we have other names such as "fireballs" and "bolides" but these refer only to larger types of meteorites and we shall ignore them. The objects so often referred to as "thunderbolts" have nothing to do with meteors, or, for that matter, with thunder, but are of mineralogical origin. The meteorites enter the atmosphere of the Earth with velocities varying from about 8 miles per second to about 45 miles per second, depending on whether they are overtaking the Earth or meeting it head-on in its path through space. As they move down into the denser region of atmosphere they compress the air in front of them and considerable frictional heat is generated. At heights of 50 to 60 miles they become so hot that the outer layer of the meteorite vapourizes to form an incandescent mantle round the particle, many times its size. It is the passage of this glowing gaseous envelope through the atmosphere which causes the luminous streak of light we call a falling star. It should be noted that the particle itself is much smaller than the incandescent envelope; in fact most falling stars are no larger than a drop or two of water. The height at which the meteor first becomes visible depends upon its velocity of entry into the tenuous atmosphere, and generally ranges from 80 to 50 miles. As the meteor passes down through the atmosphere, which becomes denser as the particle gets lower, it both burns away and slows down. The height at which the meteor becomes invisible depends again on its size. If it is a small particle, generally it will completely burn away, but a larger particle will disappear when it has slowed down sufficiently so that the frictional heat is not enough to make it glow. Such a particle may eventually reach the surface of the Earth. The average length of visible path is about 200 miles, the meteor streaking across the sky at a small angle of inclination to the surface of the Earth. The path generally ends at a height of about 20 miles, although occasionally some particles have been seen as low as about 8 miles.



Orbit of Leonid meteor swarm, cutting orbits of Mars, Jupiter, Saturn, Uranus, and touching that of Earth. (Not to scale)



An aerial view of the meteor crater in Arizona, U.S.A. The crater is 600 feet in depth and four-fifths of a mile across. The specks on the edge are stone blocks weighing thousands of tons

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Number of Meteorites.

We have already mentioned the existence of meteor swarms, such as the Leonids, which may cause a brilliant display. There are many other such swarms which occur at regular intervals, the reason being that these swarms travel along well-defined paths, or orbits, round the Sun. These paths are elliptical in shape, and pass across the orbit of the Earth at regular intervals as they circle round the Sun to move out towards the edge of the Solar System. The diagram shows the orbit of the Leonid swarm, where it is seen that it crosses the orbits of the Earth, Saturn and Jupiter. It takes 33 years for the swarm to travel once round its path, so that we may expect a brilliant meteor display about once every 33 years. We get a smaller display each November because the Earth cuts across the orbit at this time each year, and there are always a few stragglers from the main swarm. From the point of view of space travel, we are not particularly concerned about these swarms. Although they would constitute a grave danger to a rocket ship which happened to meet them, since their locations are known in advance they could always be avoided.

We are mainly interested in the meteorites which are near the Earth. Until the advent of radio astronomy, our knowledge of these sporadic meteorites was based upon visual, or photographic, observations of the falling star tracks. These tracks last for about one second, and one observer can see between 5 to 10 per hour, depending upon the season and the time of night. We see about twice as many after midnight as in the early evening. This is because after midnight we are on the side of the Earth which is "in front" as we move round the Sun. In this case we see not only those particles which catch up with the Earth, but also those which the Earth overtakes. For this reason the average velocity at which the meteorites enter the atmosphere is greater after midnight than it is before.

If we look at the sky to observe falling stars we are seeing things which take place at a height of about 50 miles, on the average. We see about one hundred-thousandth of the total area of the sky at this height. If we see 10 meteors every hour, this means that in 24 hours, 24 million meteors must enter the atmosphere, since they are coming in during daytime as well as at night. This enormous number only includes those large enough to see. Photography and radio show that there are many more than this; in fact the total number of meteorites entering the atmosphere every 24 hours is thought to be about 750,000,000,000,000,000 (seven hundred and fifty thousand million million). This enormous number is completely beyond the power of the imagination to visualize. On the other hand the average weight of these particles is very small, so small in fact that the weight of all these particles if collected together would only be a few tons, and they could all be packed into about five tea chests. The majority of

these particles are smaller than a grain of sand, and only about six million of them are larger than one tenth of an inch across. The number that are large enough to reach the surface of the Earth is about 12. Only 4 or 5 per year are actually seen to fall. Very occasionally a really large meteor, or a group, falls to the surface of the Earth. The greatest recent fall was in 1908 in a remote part of Siberia. Trees were blown down by the blast and scorched up to a distance of 20 miles away. Every thousand years or so an exceptionally large meteor hits the Earth's surface, making a huge crater. There is such a meteor crater in Arizona. It is about a mile wide and 600 feet deep in the solid rock. Tons of meteor fragments have been collected from the vicinity. The meteorite causing this crater, which fell in prehistoric times, must have weighed over a million tons. The largest meteor ever found weighs about 60 tons.

Properties of Meteorites.

Chemical and spectral analysis of meteorites shows that they can be divided roughly into three groups. There are those of pure iron, or iron with some nickel, called siderites; those of about equal parts of iron and stone, called siderolites; and finally those of a stony nature called aerolites. There are no materials in them not already found here, which suggests that they originate in the Solar System. The stone particles outnumber the iron type by about ten to one, but size for size the iron ones are heavier and would therefore constitute a greater danger to a spaceship. Radioactive measurements indicate that most meteorites are very old, ages up to three thousand million years having been calculated, so that some of them seem to be about as old as the Earth.

By observing (from two stations) the brightness, length of path and velocity of falling stars against the background of known stars, the approximate orbits and sizes of the meteorites can be calculated. Nowadays they can also be tracked by radar methods. Nearly all the particles seem to have a velocity of less than 26 miles/second relative to the Sun. This can be shown to mean that their orbits are ellipses and that they are therefore confined to the Solar System.

Distribution of Meteorites.

Meteorites differ greatly amongst themselves in size, weight and velocity, but we must know in more detail how these properties are distributed before we can assess with reasonable accuracy the result of a collision between a meteorite and a spaceship. Since the question of velocities is the easiest, we will discuss that first.

A large stony meteorite. Shows the characteristic rough surface of stone meteorites

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A metallic meteorite (the Otumpa Meteorite). The surface is fairly smooth and shiny, and of a dark blackish-brown colour. Weight about 1,400 lbs.

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We are not particularly interested in the actual velocity of the meteorite, but rather in the velocity with which it would collide with a spaceship, and this, of course, will depend also upon the rocket's velocity. In order to have a margin of error on the safe side, we must consider it at its worst. If we can afford protection against the hardest collisions, then we need not worry about any other type. We need therefore consider only collisions taking place at the greatest speed of impact. Now the maximum velocity of the meteorite itself will be 26 m./sec. The Earth is moving round the Sun with a speed of 18·5 m./sec., so that the maximum velocity at which a meteorite could enter the atmosphere is about 45 m./sec. The minimum velocity at which a spaceship could leave the Earth (escape velocity) is about 7 m./sec., so that the velocity of collision could be about 52 m./sec. If we use this figure to assess the damage due to collisions then we will probably be on the safe side.

The damage done by collision depends not only upon the velocity of impact but also upon the size of the colliding particle. For any particular type of meteorite there are very few large ones, but a very large number of small ones. In fact there are so few large meteorites that the chance of a collision with one is too small to bother about. It is only when we consider the smaller meteorites that the chances of collision become high, and although the number of particles near the Earth is very large, so is the space they have to move in. In fact the distributional density is quite small and it is thought that the average distance between one meteorite and its nearest neighbour is several hundred miles.

Chance of a Collision.

The fundamental problems are what is the probability of a collision taking place, and how many of these collisions would be liable to cause serious damage? The problem has been examined by Grimminger,[1] Ovenden,[2] and Langton.[3,4] Grimminger[1] studied the problem of a spaceship whose surface area was 1,000 sq. ft. at a height of 300 miles above the Earth's surface. By the use of statistics he was able to work out the chance of a hit occurring, and the probable time between consecutive hits. He also worked out the resulting penetration of the hull of the spaceship when it was hit by stone meteorites of various sizes. We have mentioned above that iron meteorites, although less frequent than stone ones, would do more damage, and the effect of a collision with an iron meteorite was worked out by Ovenden.[2] Both these workers assumed that the resultant damage would be mechanical, and that the whole of the energy of motion of the colliding particle would be used in breaking through the metal of the hull. It is likely that a considerable amount of heat would be generated on collision and that the hull would melt in the region of collision, so that we would also have thermal penetration. The amount of thermal penetration was calculated by Langton[3] for both iron and stone meteorites, and also the best material for protection was found,[4] which aspect will be mentioned later. In Table I below we give some of the results quoted by Grimminger.[1] This shows the number of meteorites entering the atmosphere and their masses, together with their diameters. It should be realized that owing to the observational difficulties these figures are liable to inaccuracy. Table II shows some of Grimminger's results when he calculated the chance of a collision occurring between his spaceship 300 miles up and various sized particles. He gives, amongst other results, the average time which would elapse between two collisions of the same sized meteorite.

TABLE I

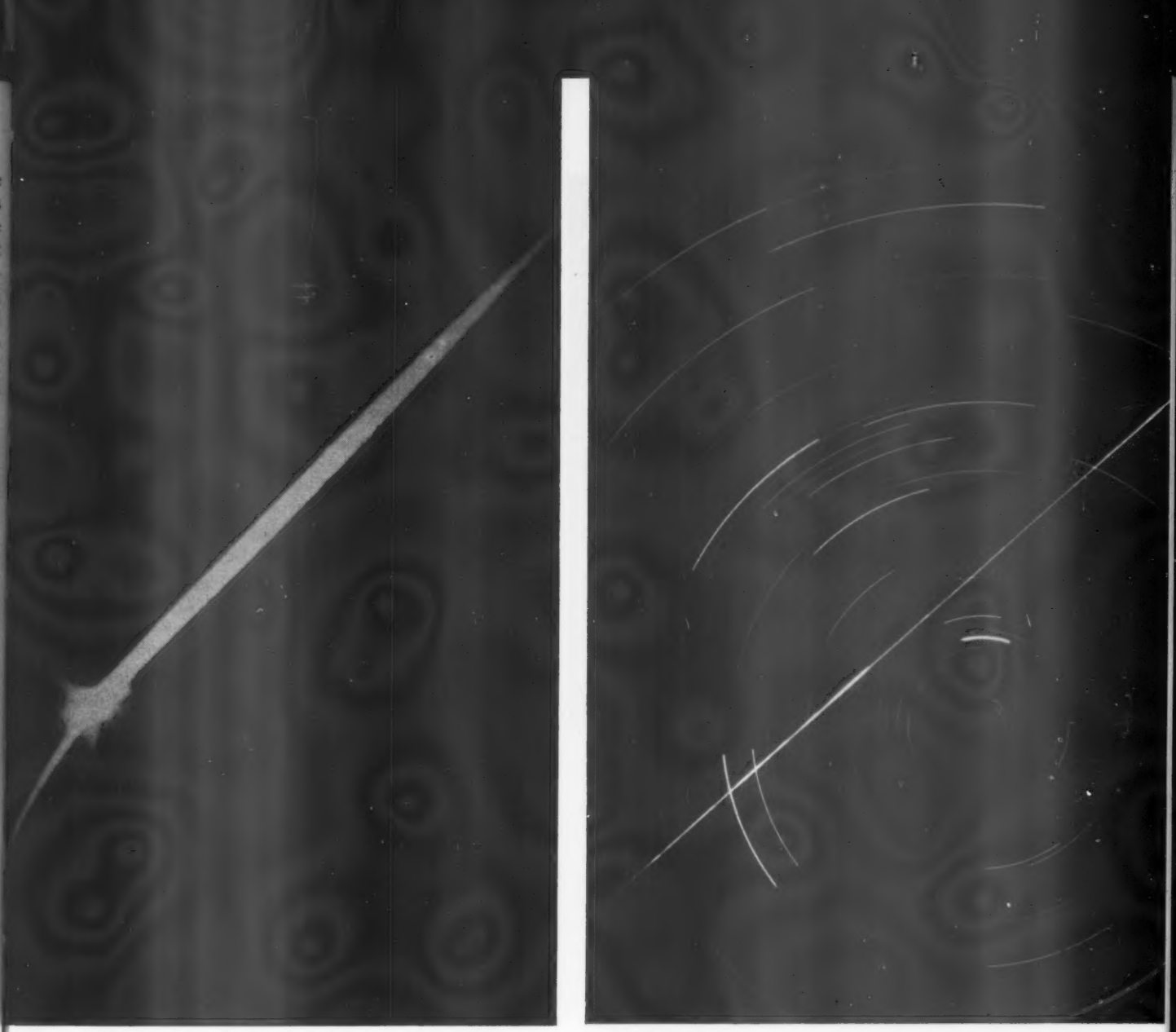
MASSES, SIZES AND FREQUENCIES OF METEORITES

Diameter in inches (assumed spherical)	Mass in lb.	Frequency (No. in 24 hours)
0·205	$5{\cdot}51.10^{-4}$	450,000
0·151	$2{\cdot}20.10^{-4}$	1,100,000
0·111	$8{\cdot}72.10^{-5}$	2,800,000
0·082	$3{\cdot}53.10^{-5}$	7,100,000
0·060	$1{\cdot}39.10^{-5}$	18,000,000
0·044	$5{\cdot}51.10^{-6}$	45,000,000
0·033	$2{\cdot}20.10^{-6}$	110,000,000
0·0238	$8{\cdot}72.10^{-7}$	280,000,000
0·0177	$3{\cdot}55.10^{-7}$	710,000,000
0·0129	$1{\cdot}39.10^{-7}$	1,800,000,000
0·0095	$5{\cdot}51.10^{-8}$	4,500,000,000
0·00205	$5{\cdot}51.10^{-10}$	450,000,000,000

(*These figures are for stone meteorites having a density of* 212·26 *lb./cu. ft. An iron meteorite of the same mass as a stone one has a diameter of about* $\frac{3}{4}$ *that of the stone particle.*)

In Table I the largest meteorite tabulated has a diameter of 0·205 inches, which is about the same size as a small drop of water. A meteorite larger than this is so rare that we need not include any in the table. The chance of a spaceship being hit by a meteorite larger than the first one in the table is less than one chance in several million. As we move down the table the size and mass of the particles diminish, but the frequency increases enormously, and so therefore does the probability of a collision. The larger meteorites near the top of the table are about the size of grains of sand, whilst around the centre we are dealing with particles about the same size as particles of dust. A particle of diameter 0·033 in., for example, has about the same size as a fair-sized speck of dust, and its weight is about one thirty-thousandth of an ounce. At the bottom of the table the particles are about twice the size of the water droplets in a fog.

One's first reaction to the size comparisons given above is that the meteorites are so small that no damage at all would be caused by a collision. We can show, however, that this is unfortunately not the case. The amount of damage caused by a colliding particle depends not only upon its mass, but also upon its velocity of collision; in fact the deciding factor is half the product of the mass of the meteorite with the velocity of collision squared, called the Kinetic Energy. If we work out the energy possessed by the meteorite mentioned above, which has a diameter of 0·033 in. and assume a collision velocity of 40 m./sec. (or 144,000 m.p.h.)—which is less than the



(*Left*) A meteor exploding over South Kensington, photographed by Butler, 1895
(*Reproduced by permission of the Director, The Science Museum, London, S.W.7.*)

(*Right*) Photograph of a bright meteor, taken at Sidmouth, 1922. The camera was pointed towards the Celestial Pole and exposed for 2 hours 14 minutes to obtain the curved star tracks. The short thick curve near the centre is the track of the Pole Star. During the exposure the meteor flashed across the sky producing the diagonal straight line
(*Published by permission of Hutchinson's, London. Reproduced by L. Moulder*)

A large metallic meteorite with embedded diamond
(*Published by permission of the British Museum (Natural History)*)

A large stony meteorite
(*Published by permission of the British Museum (Natural History)*)

maximum that could occur—we find that the energy dissipated on collision is almost exactly the same as that which would be dissipated by a 100 lb. weight moving at 30 m.p.h. (The actual figures are, energy = 4.10^{10} ergs approx. and equivalent mass at 30 m.p.h. = 98·4 lb.) Such a quantity of energy could do more damage than it would be safe to ignore.

Table II gives some idea of how often various types of collision could be expected.

TABLE II

CHANCE OF A COLLISION

Size of meteorite, diameter in ins.	0·205	0·044	0·00952
Average number of hours between two hits	$3{\cdot}4.10^{8}$	$3{\cdot}4.10^{6}$	$3{\cdot}4.10^{4}$

(One year = 8760 hours = $8{\cdot}76.10^{3}$.)

This table shows that the time between one hit and the next one—for a meteorite of diameter 0·044 in. or larger—is about 400 years. This time between hits only becomes significant for particles of diameter down to 0·0095 in. The results in Table II are very approximate, however, and in any case this table does not tell the whole story. The chance of a collision with a relatively large meteorite is never zero, and no information can ever be given as to the order in which collisions would take place. Even though the chance of a collision with a small particle is much larger than that with a large one, there is no guarantee that the spaceship would not meet with a larger meteorite fairly early on in its voyage. We must work to as large a margin of safety as possible and include in our considerations the effects of a collision with the rarer but more dangerous larger type of particle.

Effects of a Collision.

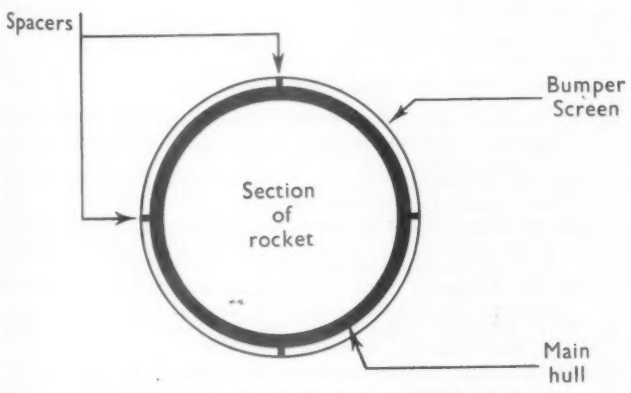
When a collision takes place between a fast moving particle and a plate of metal, some of the energy of the colliding particle will be used in breaking into the metal surface at the point of impact. If the particle has enough energy, it may break through completely and fly out of the other side. In this case the hole formed would be not much larger than the area of cross section of the particle itself, except for cracking, and fraying at the exit side. This assumes that the particle hits perpendicularly to the surface; an oblique collision would cause more damage. If the particle has less energy it will just dent or groove the surface. This type of penetration we have called "mechanical penetration". On the other hand we have the second type of penetration mentioned previously called "thermal penetration" when some of the energy of collision appears as heat. In this case the energy would be conducted through the metal plate from the point of contact and, if there is sufficient energy, a large portion of the metal might be raised to its melting temperature or even vapourized. The area of damage might be much greater than in the previous case. It is not possible to say how much of the energy of collision would come out as heat and how much would be used in mechanical penetration. The only information on the subject seems to be that dealing with the penetration of armour plates by bullets. This is unreliable from the point of view of meteoritic penetration because the particles are too large and the velocities too small compared with those of meteorites, although these data had to be used by Grimminger for the lack of any others. The method of obtaining some idea of how much damage would be done by a meteorite hitting the metal plates of the hull of a spaceship is to work out two extreme cases. Firstly we consider that all the energy is used in mechanical penetration, and then secondly we assume all the energy to be used in thermal penetration. By adding together the penetration distances so calculated for various collision conditions and different metal hulls, we arrive at the total penetration, which will be a little too large owing to other sources of energy loss. The error will be on the safe side, and in any case we are not worried about extreme accuracy because the data available are by no means accurate. For full details of these calculations reference should be made to Grimminger[1] and Langton.[3,4]

We find that in the case of the very small particles such as those at the bottom of Table I, the amount of damage caused, even for high velocity collisions, would be superficial only. The effects would be a scratching or denting of the surface of the hull, together with discolouration due to the heat effects. This does not sound very serious, but it must be remembered that such collisions would be occurring at the rate of thousands every hour. It may be that the hull would gradually become weakened as it became more and more pitted, but the gradual darkening of the outside surface might be more serious, as it would increase the absorption of heat radiation upsetting the temperature conditions inside the spaceship. Collisions with the slightly larger types of meteorites would cause some penetration producing small holes in the hull. These holes would be no larger than pin holes but would increase the leakage of air from the vessel and would be difficult to find inside the ship. We are more concerned with the larger sized meteorites about the size of a grain of sand. Although these would only cause a small hole if the penetration was purely mechanical, the thermal effects would be considerable, and large sections of the hull might be vapourized on collision. It can be shown that if a meteorite of diameter 0·205 in. collided with the hull of a spaceship with a collision velocity of 76 km./sec., which is quite probable, the portion of the hull at the point of impact would be raised to a temperature of over 4,000,000° C. The effect of this would be to vapourize explosively a large section of the hull. This, of course, assumes that the whole of the energy of collision came out as heat, but even if only a fraction of this did so, the result might still be serious. It is, however, the possibility of this enormous evolution of heat that leads us to a proposed method of protection against the effects of collisions.

Bumper Screens.

The idea of protection against the effects of meteoritic collision by the use of a bumper screen was first suggested by the American astronomer Whipple.[5] The idea is that the main hull of the spaceship be completely surrounded by a thin sheet of metal held a distance of about an inch away from the surface by spacers. A colliding meteorite would then hit this bumper screen first, and lose most or all of its energy here, vapourizing a portion of the screen and itself as well, hence protecting the main hull. Even if the meteorite were so large that it did not completely disappear on hitting the screen and got through to the main hull, it would cause far less damage than it would on direct collision. This form of protection would still be effective even if the penetration effect were purely mechanical, which is extremely unlikely.

The amount of mechanical penetration for such a screen made from dural or stainless steel was calculated by Grimminger[1] for the case of stone meteorites. Calculations for aluminium and chrome steel screens were made by Langton,[3,4] who also calculated the thermal penetrations for these four materials, for both iron and stone meteorites. It can be shown that the best material for a bumper screen is chrome steel, both from the point of view of protection and also of weight. A bumper screen of thickness 0·104 cm. or 41 thousandths of an inch made from chrome steel would weigh about 0·81 tons per 1,000 sq. metres and would give protection against the smaller sized meteorites with which collisions are liable to occur more than about once every two years. By increasing the thickness of the screen, more protection against the larger sized meteorites is of course possible, but it must be remembered that the weight of the screen is important until more powerful rocket fuels are invented. Such a bumper screen will also give partial protection against the larger sized meteorites which will lose some of their initial energy in penetration. Whipple himself suggested a screen of thickness 0·25 in. This would give adequate protection against all but the very large particles, but such a screen would be rather too heavy for any spaceship we can visualize at the moment even if we adopted a partial screen on the grounds that collisions would tend to occur at the front end of the rocket only.



How a bumper screen would be fitted

A typical comet

There is no reasonable practical method of affording protection against the larger type of meteorite, but for a flight within the Solar System to the Moon, Venus or Mars, which would only last a few months, at the most, the chance of collision is too small to be significant. It is only when we consider an interstellar voyage, with its correspondingly longer time in space and higher velocities, that we need worry about more violent collisions. Since an interstellar flight could only be made either by using some form of atomic fuel, or by starting from a space station, in either case the question of the weight of the bumper screen would be less important and much thicker ones could be used. These higher velocities would mean the risk of a collision taking place with a meteorite moving with a velocity more than 52 m./sec. with respect to the spaceship. It can be shown that as the velocity of collision increases, so does the thermal penetration outweigh the mechanical more and more. At relatively low velocities of impact the mechanical penetration is greater than the thermal. This is obviously so from everyday observations of low velocity collisions. With an impact velocity of 76 km./sec. (47·4 miles/sec.) the thermal penetration is 0·04 in., whilst the mechanical penetration is about 0·13 in. Thus in the case of an interplanetary flight of a spaceship which can just reach the escape velocity of 7 m./sec. so that the maximum velocity of impact would be about 52 m./sec., the greatest source of danger would be the mechanical penetration of the hull. The above figures refer to collision between an iron meteorite of diameter

0·0095 in. and an aluminium screen; in the case of a chrome-steel screen the mechanical penetration would be about 0·04 in. and the thermal about 0·033 in. Thus the difference between the two types of penetration depends upon the bumper screen material. A detailed investigation shows that for all the screen materials considered, there is some velocity of collision at which the mechanical and thermal penetrations are equal, and that this velocity is the same whatever the size of the colliding meteorite. In the case of a chrome-steel screen, which would be the best material to use, the two types of penetration become equal at an impact velocity of about 670,952 m.p.h., or 130 km./sec. Above this velocity the thermal damage would be greater than the mechanical. Thus at the moment, when we are thinking only of chemically propelled rockets and velocities not much greater than that of escape, we should design our bumper screen from the point of view of mechanical penetrations. If, as is more likely, our spaceship sets off not from the Earth, but from an artificial satellite so that greater velocities can be acquired, or we find a method of harnessing atomic power to give larger velocities, then the danger from thermal penetration would tend to predominate more and more the faster we travelled. The velocity of 670,000 m.p.h. mentioned above, however, is about 27 times as great as that of escape, which is 25,000 m.p.h. approximately, so that it is unlikely that we shall have to cope with collisions at this velocity for a long time.

Conclusions.

We have seen that the total number of meteorites entering the atmosphere of the Earth every day is enormous. In spite of this fact, the chance of a dangerous collision occuring between a meteorite and a spaceship is very small, because meteorites large enough to cause such damage are few and far between, and a spaceship would be such a relatively small target. If we are considering journeys which would only last a few days or even a few weeks, the chance of a collision taking place with a meteorite larger than a grain of sand is very small. We could however prevent such small meteorites from damaging the hull by using a bumper screen. This would be necessary because even though the meteorites just mentioned are very small, the number of collisions occurring every hour would be large, and after several hours the accumulation of damage might become serious. We could not protect against collisions with the larger meteorites, but these collisions would be very infrequent. The result of such a collision would be that the particle would tear and burn a hole through the bumper screen, and have sufficient energy left to do the same to the main hull. The meteorite would probably be stopped before it went very far into the interior of the spaceship, however, because it would almost certainly hit equipment fastened to the interior wall of the vessel. Although the damage caused would be severe, it might not be fatal, and the leak in the hull could be easily sealed by placing over the hole a rubber sucker which would be held on by the internal air pressure. Damage to vital apparatus and fuel tanks could be prevented by extra screens at these points. As far as we know at the moment, however, such collisions would be extremely unlikely to occur.

The above conclusions have to be modified when we consider a manned satellite. This would remain in space for a very long time, in fact since one would be so expensive to put up, once up it would probably remain there indefinitely, outworn parts being replaced by new ones. In this case then we would expect to have a few collisions taking place between the satellite and the larger sized meteorites. Protection however would now be easier. We would not have to bother so much about weight, and thicker bumper screens could be used, being brought up in sections from the Earth. A quite feasible method of protection would be to throw out of the artificial satellite any unwanted or worn out equipment. This could be tethered so that it remained near the satellite, and would act as a very efficient bumper screen, so that after several years the satellite would become immune from meteorite collisions by being surrounded by a cloud of junk.

Finally, it must be emphasized that the figures relating to meteorites, mechanical and thermal penetrations are only tentative, and we shall not know what really happens on collision until we can take our spaceship out into space and find out by experiment. Even now, however, there is a small amount of experimental data available on the subject, and collisions between meteors and rockets have actually been recorded. Experiments performed in America using V2 rockets were reported in 1954.[6] These rockets ascended to altitudes of about 90 miles, and meteoric collisions were observed to take place from a height of about 25 miles. The collisions were detected in two ways. It was possible to see microscopic pits in the outer surfaces of the returned rocket, and also the noise of the impacts was detected by microphones and transmitted back to the ground. Although this work was done in the upper atmosphere and not in free space, the results do seem to confirm, as near as can be expected, the predictions about collision frequencies described above.

It appears then, that as far as we know, there is more chance of returning from a space flight than was once thought. In fact it seems that the reader would be in far less danger of being hit by a meteorite in space than of being hit by a car in the average city street.

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Hermann Ganswindt—The Traditional Inventor

By G. V. E. THOMPSON, B.SC., A.R.C.S., F.R.I.C., A.I.L., L.I.M.

In the first article in this series I mentioned that the underlying principle of astronautics seems to have been conceived independently by two men—K. E. Tsiolkovskii and Hermann Ganswindt—at about the same time. Ganswindt was the first to get his ideas published, and therefore deserves our consideration. However, as will be seen, his ideas were far from being at all practicable, and space flight was but one of his many interests—and a very minor one at that. In fact Ganswindt seems to have been a good approximation to the traditional idea of an inventor—an impoverished person building improbable-looking machines that nobody wanted, and which were put together with string and sealing wax. But even if he had nearly as many inventions to his credit as the White Knight, Ganswindt certainly did not have the same mild temperament. Of course, he could not fight his battles with lance and sword in the lists—he had to resort to the modern substitute, the law court.

G. V. E. Thompson

He was not always fond of the law, though even when young he appears to have been pugnacious. Born of well-to-do parents in a small East Prussian town on June 12, 1856, he was originally intended for the legal profession. But this was not to his liking; he rebelled against his parents and became an inventor. At any rate, that was the final result; Ganswindt could never do anything as simply as that. In renouncing his legal career, he had to write a book to say just what he thought about the law and the administration of justice. He was not a man who was afraid of expressing his opinions.

His first invention was the airship, and here we have another parallel with Tsiolkovskii, who also interested himself in dirigibles. So did many other people, for Ganswindt was by no means the first inventor in this field. Dirigibles had indeed been built, but none of them had been particularly successful, which was only to be expected as the only power plant available was the steam engine. Ganswindt reasoned that if this had to be used, the size of the vessel would have to be increased. If this were done, the volume (and thus the lifting power) would increase at a greater rate than the air resistance.

This argument is not unreasonable, and the results of his calculations may well have been correct, but they were not well received. They amounted to a proposal to construct a dirigible five hundred feet long and fifty feet in diameter. This was not an impossible engineering feat even in 1883, when Ganswindt obtained a patent for this invention, but it was well beyond his resources, so he set about trying to persuade the Prussian government to build such an airship for military purposes. Correspondence with the army being unfruitful, he set down his proposals in another book—*Die Lenkbarkeit des aërostatischen Luftschiffes*. This was printed at his own expense in July 1884, and he immediately sent copies to various people of influence, including the Crown Prince, the future Kaiser Friedrich III.

This resulted in a minor success; the Crown Prince actually read the book, or at least skimmed through it. He ordered an official investigation into the proposals. The Generals in the War Ministry were displeased — they wanted nothing to do with flying machines; horses were quite good enough for them—but they had to comply. The proposals were passed to experts for investigation. Unfortunately, they could find nothing wrong with Ganswindt's arguments. But civil servants know more ways of dealing with a matter than just approval or disapproval. They merely reported that airships five hundred feet in length surpassed immediate military requirements. With that answer they would be safe however things developed.

It was not an answer which would satisfy Ganswindt, so he tried to obtain support from other quarters, even founding a society for this purpose. But he did not remain content with a single invention; he obtained a small factory and set to work. He devised a mechanism worked by a treadle and installed it in a boat and a carriage. The appearance of the horseless carriage in the Berlin streets resulted in another success, but again not an unqualified one. The fire department asked him to build them an engine; he did so, and they were satisfied enough to wish to buy it. This could have been the start of a successful business, and Ganswindt might have developed into an automobile millionaire. But he was too cantankerous for that. He asked for more money than the city could afford; when they were unable to meet his demands, he took back the fire engine.

He also devised a free-wheeling mechanism for

bicycles, but more important from our point of view is his interest in spaceflight. We are not certain when or how this first developed—possibly as a result of reading novels about interplanetary travel. The first record of his interest is given in newspaper reports of a lecture on the subject given on May 27, 1891, at a concert hall in Berlin.

He understood that the principle of reaction offered to us the possibility of crossing space, but he did not understand it fully, and his design for a spaceship bears little resemblance to the rockets of today, let alone the vehicles which will eventually make the journey. The "fuel" was dynamite, packed into heavy steel cartridges, which were fed one after the other into a bell-shaped chamber and detonated. Ganswindt visualized one half of the cartridge going downwards, the other going upwards and knocking on to the top of the chamber, thus giving it an impulse upwards, after which the spent shell would also drop downwards. The succession of charges would suffice to propel the whole vehicle upwards from the Earth, though in a rather jerky motion. Two magazines, one on each side of the explosion chamber, held a supply of cartridges, and beneath the assembly was suspended the cylindrical cabin. It had a hole through the centre to permit the remains of the cartridges to pass through without causing any damage. Needless to say it is most unlikely that such a contraption would have risen from the ground at all—the most probable consequence (if anyone unwise enough to build it had been found) would have been that all of the dynamite would have gone up in one big explosion.

Ganswindt does seem to have realized that when one was travelling freely through space the problem of weightlessness would arise, for he arranged to have the vessel rotated, so as to set up an artificial gravity. He might have developed a more reasonable form of spaceship if he had applied himself to the subject. But other things became more important to him.

He invented a helicopter. A rather primitive type of helicopter, but one that did rise from the ground. It could not fly any distance, because it was driven by the action of a falling weight. If a suitable internal combustion engine had been available at that time, it might have been developed eventually into a flying machine. But not with Ganswindt in charge. He had a number of enemies, probably disappointed investors. They claimed that the helicopter was a fraud. An official investigation disproved this, but that did not satisfy Ganswindt. He dragged his opponents into court, and began a series of lawsuits. The cases went from court to court, and he also sent petitions to the Government. This went on for years; he was bitten with the idea that he was being persecuted. Instead of going on to fresh inventions, he devoted the remainder of his life to seeking recognition of his place as the original inventor of the automobile, aeroplane, airship and spaceship.

And in the end he did get some recognition, of a kind. In 1934, after the Nazis had come to power in Germany, one of their agencies sent him a gift of 1,000 marks. A week later, on October 25, 1934, he died.

Ganswindt was not one of the great pioneers of astronautics; his ideas in this field were too impractical and were not carried far enough. But he has a place in the history of spaceflight as being one of the first to think seriously about the subject, and one who helped to arouse interest in the problems that must be surmounted.

The New Comet

On November 8, 1956, Arend and Roland, at Uccle, discovered a new comet. It was found upon a photographic plate exposed to record minor planets, and was a faint object, but interest was aroused when enough observations had been made for an orbit to be computed, as it became clear that the comet might become a brilliant object.

Really bright comets have been rare of late. The last object to deserve the title of a "great" comet appeared as long ago as 1910; there have of course been naked-eye comets since then, but none spectacular enough to arouse general interest except among astronomers themselves. At the time of writing (March 12, 1957) it is calculated that the new object known technically as Comet 1956*h* and more commonly as Comet Arend-Roland, may be a brilliant feature of the evening sky in April. About April 12 it is thought that the magnitude will be about −0·9, so that the brilliancy will then be greater than that of any star in the heavens apart from Sirius.

On the other hand, the comet will be very low down, and will set soon after the Sun; moreover, all comets are unreliable things, and it is quite possible that Arend-Roland will not come up to expectations. All we can say as yet is that "there may be a bright comet visible in April". It will fade rapidly, and by the end of May will have ceased to be visible to the naked eye.

Woomera

By A. V. CLEAVER

Some information about the leading rocket ground of the British Commonwealth

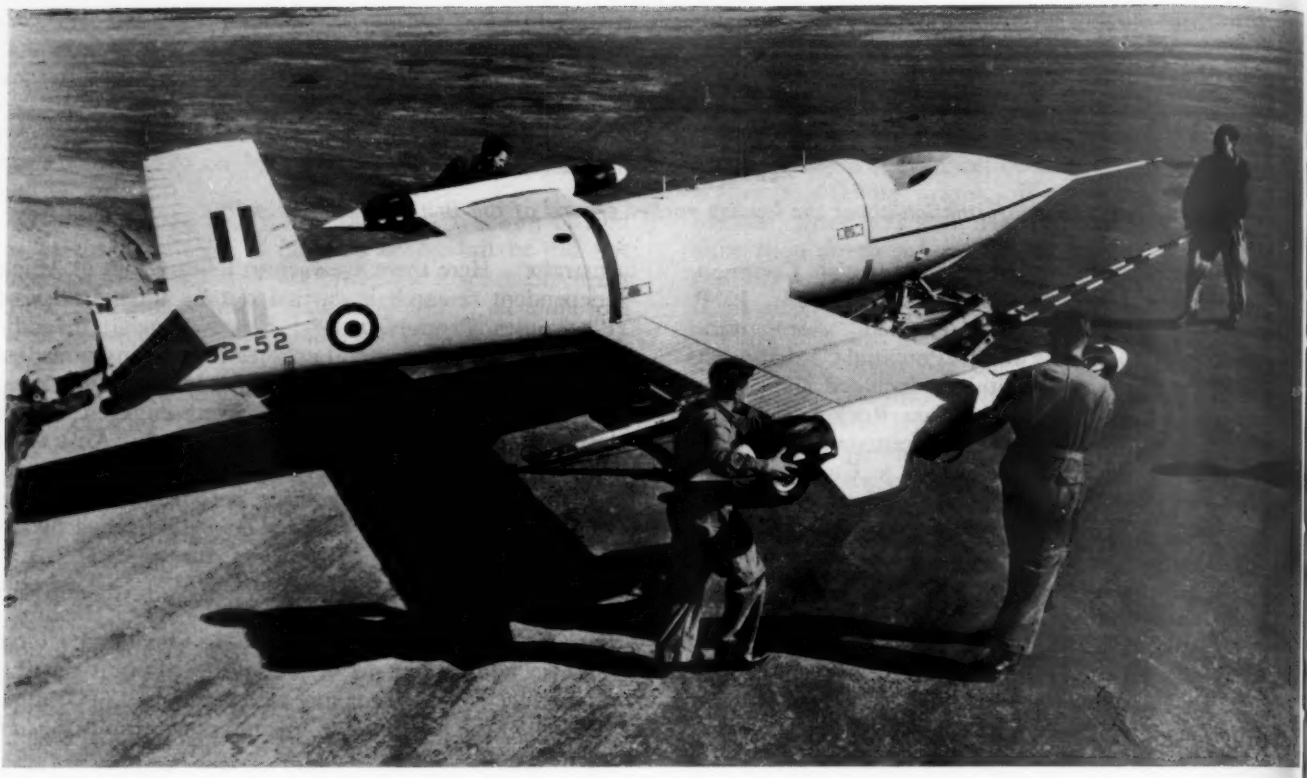
The Royal Aeronautical Society's British Commonwealth Lecture for 1956 was delivered by Mr. L. P. Coombes on November 22. Entitled "Aeronautical Development in Australia and Its Potential Contributions to the British Commonwealth", it included some interesting information on the Woomera Rocket Range.

Recalling that this facility was the outcome of a request made by Sir Ben Lockspeiser to a Commonwealth Aeronautical Research Conference in London in 1946, the lecturer described it as the finest testing ground of its kind in the world. Sir Ben had apparently asked for "a desert", and the Dominion was able to offer him one (this was when he was Chief Scientist of the Ministry of Supply). It is interesting to reflect how rocketry has so greatly increased the real estate value of the more desolate regions of the world.

The supporting base establishment is at Salisbury, some 16 miles north of Adelaide, the capital of S. Australia. Here there are various laboratories at which independent research is carried out by three Divisions (Electronics, Propulsion, and Aerodynamics); in addition, these provide general engineering and instrumentation services for the Range itself. In the same area, there are located a number of firms engaged in the development of guided weapons, mostly Australian branches of British aircraft companies.

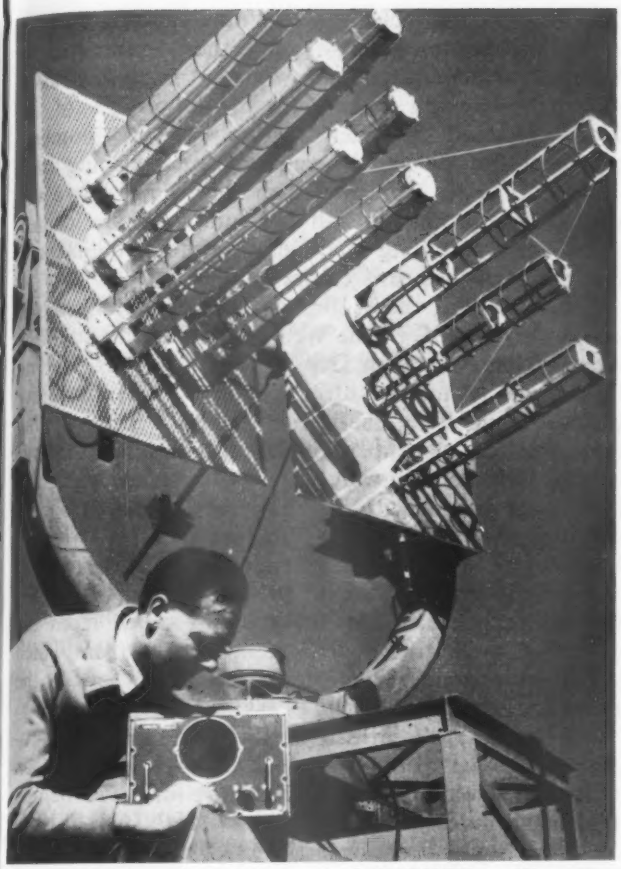
Also at Salisbury is a large aerodrome known as Edinburgh Field (it having been officially opened by the Duke), which is the terminal of the special R.A.F. Transport Command service from the U.K. to Australia. At present operated by Handley-Page "Hastings" aircraft, this will shortly employ de Havilland Comet II's also, and it is a major factor in making it possible to conduct field experiments at Woomera, 12,000 miles away from the main design, manufacturing and research organizations concerned.

Township of Woomera, South Australia, site of the Joint British-Australian Guided Weapons Development Programme, South Australia. Although this is a barren area, scientific planting of trees will later improve amenities in the township proper



This photo shows the JINDIVIK pushed on taxi-way preparatory to taking off, at Woomera, South Australia. The wing tip pods contain cameras which record the miss distance of weapons fired against it.

JINDIVIK with starter unit ready for take-off, at Woomera, South Australia



Radar aerial used to plot course of JINDIVIK, at Woomera, South Australia

With the use of binoculars the Batsman at one end of the air strip lines up the aircraft for take-off and landing

Long range movie camera which photographs JINDIVIK in flight

All the photographs reproduced in this article have been provided by the Australian News and Information Bureau, to whom we are much indebted for their help and courtesy

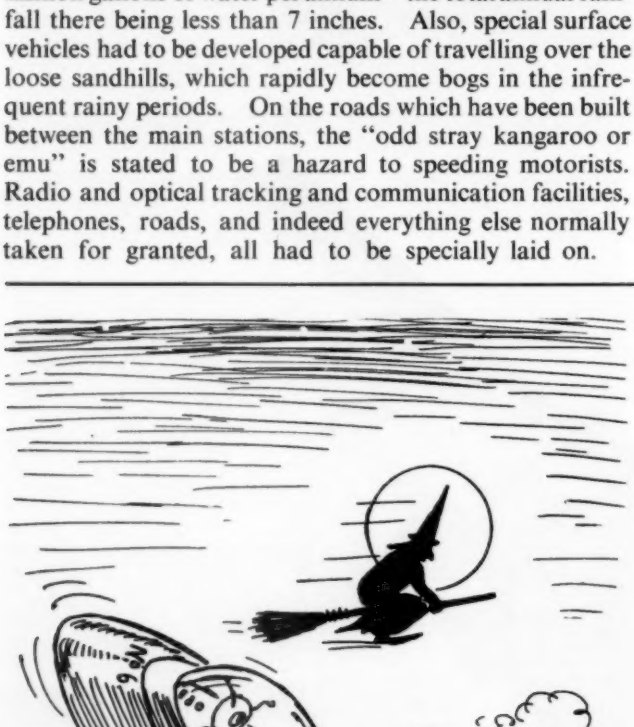
Woomera itself is several hundred miles N.N.W. of Adelaide, and is now a township of about 3,000 inhabitants, with most of the amenities of civilized life, including a school, shops, churches, a cinema—and even a jail! A special effort has been made to comb the world for suitable plants and trees to cultivate there, and an experimental nursery is kept busy on this somewhat unexpected auxiliary research. There are two airfields, one mainly used for landing radio-controlled target aircraft.

The range itself extends some 1,250 miles in a north-westerly direction, across an open plain of desert or scrub territory. Some sheep rearing continues to be carried out there, with suitable safety precautions, and the Range also crosses an Aboriginal reserve. When future very-long-range missiles become available, the firing distance can be greatly extended across the Indian Ocean, towards the Cocos Islands. Some idea of the civil engineering difficulties encountered in setting up the Range can be gained from the fact that it was necessary to construct a pipeline 110 miles long from Port Augusta to provide the Woomera facilities with 220 million gallons of water per annum—the total annual rainfall there being less than 7 inches. Also, special surface vehicles had to be developed capable of travelling over the loose sandhills, which rapidly become bogs in the infrequent rainy periods. On the roads which have been built between the main stations, the "odd stray kangaroo or emu" is stated to be a hazard to speeding motorists. Radio and optical tracking and communication facilities, telephones, roads, and indeed everything else normally taken for granted, all had to be specially laid on.

Apart from the rocket range, Woomera of course also includes a bombing range and other weapon-testing facilities. Altogether, it is now a most impressive asset to Commonwealth research. An impression of its widely-dispersed character is given by Mr. Coombes' statement that the actual range head, or launching area, is itself 30 miles from Woomera township, where the various data-processing staff and equipment are located —the latter including ciné-film projectors, digital and Hollerith punched-card computers, etc.

Begun in 1947, the Woomera Range is administered, and mainly staffed, by the Weapons Research Establishment of the Australian Department of Supply, but its finance and technical control are the joint responsibility of the Dominion and the U.K. The full benefits of this far-sighted exercise in Commonwealth co-operation will undoubtedly be seen only after the next few years, as long range ballistic missiles and other advanced rocket weapons need to be tested. One wonders, too, whether in time the United States might not want to use Woomera —especially after the recent incident when a "Snark" turbojet-propelled cruise-type missile escaped from the control of the Patrick A.F. Base in Florida, from which it had been launched, and lost itself somewhere in the Brazilian jungles!

If ever there is a British satellite or space flight programme, as we all hope will one day be the case, then Woomera would certainly be the choice for the launching site, just as it now is for Professor Massey's high-altitude research "Skylark" rockets for the I.G.Y. Mr. Coombes did not mention this, but we feel sure he would agree.



MUST BE ONE OF THOSE U.F.O.s!

A New Use for Space Suits

By devising means for coping with living conditions on Earth, man can often derive useful ideas on how to adapt himself to life on other planets. But it had probably not occurred to anyone that the opposite process may be equally true, until the following letter appeared in *The Times* of December 21, 1956:

> Sir,—There is a growing confidence that the younger generation will be able to enjoy—if that is the right word—a journey round the Moon, and one of the simpler parts of their equipment will be a space suit which will insulate and protect them against any climatic conditions they may meet.
>
> At the same time the older generation continues to be subject to earthly climatic conditions and countless numbers of them suffer twinges and worse according to the changes in the weather. Surely our space travel scientists could devise an earthly space suit which would compensate its wearers for being too old to look forward to a lunar circumnavigation?
>
> Yours faithfully,
>
> JOHN G. GILBERT.

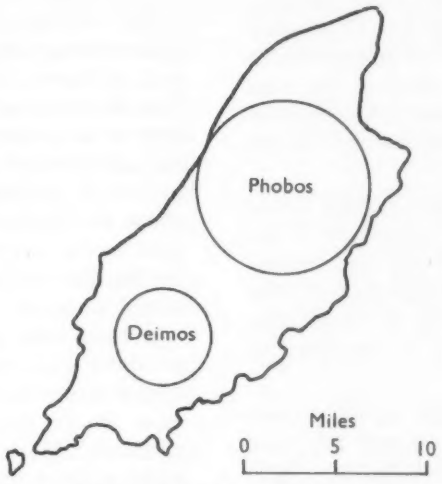
Gulliver's Moons

By DONALD MALCOLM, Secretary of the Scottish Branch of the British Interplanetary Society

Last September, when Mars made its closest approach to the Earth for 32 years, astonomers paid the planet their full attention. Among other things, they were attempting to establish or refute the existence of the famous canals and, at the same time, find out if any life exists on Mars.

However, orbiting round the red planet are two tiny moons, to which no one paid any attention at all and probably for a good reason—even the largest telescope will not resolve them into anything other than tiny points of light.

That piece of information might cause people to dismiss them as two uninteresting rocks. But there is a mystery connected with the satellites of the fourth planet. It was sparked off by the following quotation:



Sizes of Phobos and Deimos with the Isle of Man (of course, the exact diameters of the satellites are uncertain within narrow limits)

". . . They have likewise discovered two lesser stars or satellites, which revolve about Mars, whereof the innermost is distant from the centre of the primary planet exactly three of his diameters, and the outermost five; the former revolves in the space of ten hours, and the latter in twenty one and a half hours. . . ."

Many of you will recognize the above as a quotation from *Gulliver's Travels*, by Jonathan Swift, and it poses a very neat puzzle. How did Swift know of the satellites in 1726, when they were not discovered until 1877? There are two possible theories, both very shaky.

Did Swift, by a combination of extra perceptive eyesight, a good telescope and perfect seeing conditions, actually observe the moons? Having done so, did he choose to tell the world of his discovery through the medium of his book, which was a political satire, instead of announcing it formally as a scientific paper? This theory would be in keeping with the Dean's character.

Unfortunately, the theory as a whole is untenable. Assuming that Swift *did* have excellent eyesight, with the telescopes available in 1726 he could never have seen the satellites. As stated before, even the largest telescopes fail to resolve the moons into anything but tiny, luminous dots. This is, of course, hardly surprising, as Phobos, the inner moon, is thought to be about 10 miles in diameter, while the outer moon, Deimos, is no more than 5 miles across.

That leaves us with an equally shaky theory. In 1726, Saturn was the outermost planet (Uranus was discovered in 1781) and Swift might have reasoned thus: the two planets nearest the Sun, Mercury and Venus, have no moons. The Earth has one, Jupiter has four (discovered as far back as 1609) and Saturn had five known moons in Swift's day. As the number of satellites per planet increased the further out the planet lay from the Sun, Swift might have concluded that Mars ought to have two moons. Not very scientific, this, but perhaps a reflection on the times.

However, such a theory does not account for Swift's fairly accurate figures for the orbital periods or for the distances of the satellites from the planetary centre. If we take the diameter of Mars as being 4,200 miles, Swift's distances for Phobos and Deimos work out at 12,600 and 21,000 miles respectively. The observed distances are 5,800 miles and 14,600 miles respectively. The Dean's orbital periods are 10 hours and 21 hours 30 minutes, as against the observed periods of 7 hours 39 minutes and 30 hours 18 minutes.

Having rejected these two theories, we are still left to answer the problem of how Swift arrived at his figures. We can assume, of course, that the observed figures are accurate.

Swift tells us ". . . that the squares of their periodic times are very near in the same proportion with the cubes of their distances from the centre of Mars, which evidently shows them to be governed by the same law of gravitation that influences the other heavenly bodies. . . ."

In other words, the two moons obey the third law of Kepler, which states that the squares of the times of orbital revolution are proportional to the cubes of the distances of the planets from the Sun.

From this is seems that Swift based his figures on Kepler's third law, but whether or not he nominated an arbitrary set of figures is unknown.

The moons were discovered by Professor Asaph Hall in 1877, when he was using the 26-inch refractor at the Naval Observatory, in Washington.

Despite the fact that both William Herschel and D'Arrest searched for, and failed to find, any satellites of Mars, Hall commenced his search on August 10, 1877. He found nothing, but on the next night he discovered an object. Cloudy weather intervened and when he next observed, on August 15, the object was nowhere to be

seen. Its rediscovery was, however, not long delayed, as Hall saw it again on the night of August 16. This proved to be the outer moon. Fame was now within Hall's grasp. He discovered the inner moon on the next night.

Hall was puzzled by the movements of the inner moon, and he thought that there might be more than one moon inside the orbit of Deimos, the outer satellite. Observations on the nights of August 20 and 21, showed that there was only one satellite, but an unique one in that it made three revolutions round Mars in the time the planet took to rotate once on its axis. An observer on the Martian surface would see Phobos rise in the West and set in the East.

From time to time, people ask if the satellites could possibly be captured asteroids. This suggestion is not immediately unreasonable, especially when one remembers that many of the asteroids have decidedly eccentric orbits which, on occasion, take them near to the planets. Hermes, for instance, has been known to approach to within 475,000 miles of the Earth.

As the orbit of Mars lies nearer to the orbital stream of the asteroid belt, the possibility of an asteroid being captured by Mars would seem to be much higher. Both the moons are small and of low mass, and they follow the rule of the road in the Solar System, having direct motion. Supposing the satellites *are* captured asteroids, this type of motion might be expected. An asteroid that gradually spiralled in towards Mars would, if caught in the Martian gravitational field, continue to have direct motion round the planet, whose orbit lies inside the orbital stream of the asteroids.

On the other hand, if, as has been suggested, the outer satellites of Jupiter are captured asteroids, their retrograde motion is what might be expected. At their great distance from the planet, Jupiter's mighty gravitational attraction was probably powerful enough to pull them into an orbit round the planet, but not powerful enough to give them direct motion.

However, there are many other points to be considered, and if we investigate the problem mathematically it is seen that the arguments rest upon very uncertain foundations. So much for the captured asteroid theory. Another, more imaginative, is unfortunately absurd. According to this theory, the moons are actually abandoned Martian space-stations.

Let's examine this idea. To begin with, the presence of space-stations round Mars presupposes that there is not only intelligent life on Mars, but life technically advanced to a degree that enables them to establish space-stations in orbits round their planet—a project we on Earth have not achieved. Few, if any, authorities now believe, as Lowell did, that intelligent life exists on the desert world.

The technology and science of such a race would have to be centuries ahead of ours, because the "stations" have estimated diameters of 10 and 5 miles respectively! The diameters of space-stations envisaged by terrestrial experts lie in the range of about 250 feet. Von Braun has calculated that 6,000 tons of fuel would be required to carry a payload of 36 tons to an orbit of 1,075 miles above the Earth. On this reckoning, the amount of fuel used in the ferrying of material for the construction of the Martian stations, even allowing for the lesser gravity, would be great.

A brief look at the uses of a space-station will help to show that the satellites would have marked disadvantages. Apart from the advantage of having a view of the universe unhindered by atmospheric disturbance, Martian space-stations would be used for making observations of the planet itself. For example, observers would be able to ascertain the true shape of Mars, its true albedo, or ability to reflect light, predict Martian weather and keep an eye on the activities taking place on the surface of the planet.

The type of orbit most suited to observation, weather prediction and so forth, is a polar one, i.e., one that passes over the poles of the planet, or an orbit slightly inclined to the axis. As the station moves round its orbit, the whole of the planet, which is spinning below, will be accessible to the station's telescopes. On the other hand, a station in an orbit lying in the plane of the planet's equator, would be able to observe only the areas immediately above and below the equator. The regions around the pole caps could not be observed from a space-station in the same orbit as Phobos. It follows that any hypothetical Martians who lived permanently at either pole cap would never be aware of the existence of Phobos, because the inner moon is so close to the planetary surface.

Until new information turns up—if it ever does—it seems that Swift's prediction about the tiny moons of Mars will remain a mystery.

Meetings in South Shields

Members of the British Interplanetary Society who live in the South Shields area have been holding meetings at the Ocean Road School, South Shields. These meetings have been held every four weeks, but alternating between Wednesdays and Thursdays. Notices have been sent to many members living in the area, but it it possible that some may have been missed out; and should any member within reach of South Shields wish to attend these pleasant and informal meetings, they are requested to contact W. Smith at 65, Lisle Road, South Shields, County Durham.

The Problem of Weightlessness

By ALAN E. SLATER, M.A., M.R.C.S., L.R.C.P.

Everyone knows the term "zero gravity"—how conventional weight will seem to vanish during free fall conditions. But what does it really mean, and is zero gravity likely to prove dangerous?

If you say that you feel weight because the Earth is pulling you towards its centre, you are mistaken. You feel weight only because something is *resisting* the pull of the Earth. It may be the surface of the Earth itself that is resisting the pull, or a piece of furniture, or the floor of a room or a vehicle.

The vehicle floor resists your fall if it is supported on something which is in turn supported by the surface of the Earth—or of some other planet, if you have managed to reach one. This intermediate support may be solid if you are in a land vehicle, water if you are in a ship, or air if in an aeroplane.

On the other hand, if the downward pull is being resisted by the cabin floor of a rocket-propelled vehicle, once it is off the ground the Earth's surface plays no part—and the same applies on any other planet. The resistance is in this case provided by the pressure of the propellant gases against the top end of the rocket's combustion chamber.

Dr. A. E. Slater

Note particularly that, in a rocket vehicle which is out of contact with the ground, any weight you may feel is entirely due to the rocket motor being in action, because only then are the propellant gases exercising any force. Moreover, your apparent weight is proportional to the power of the motor, and will vary as the power varies. Suppose the rocket is just hovering a few feet above the ground; then you will feel your normal weight. But to get away on a space voyage, the power must be increased, so your weight increases too—in fact, in the interests of fuel economy you may be made to suffer as much increased weight as your body can stand, so as to shorten the take-off period.

But as soon as the ship has reached "escape velocity" or "orbital velocity", as the case may be, the motor is stopped, and immediately the occupants of the cabin feel no weight at all. They will continue to feel no weight until the motor is started again, either to reduce speed before landing at the destination, or during short bursts of power for correcting the course. This feeling of weightlessness is due entirely to the fact that the motor is out of action and the ship is moving through space without encountering resistance; that is, the feeling has nothing to do with any gravitational field. It makes no difference whether the body causing the gravitational pull is large or small, near or far; its pull influences the course of the ship but has exactly the same effect on the course of the occupants, so that no part of the cabin wall, roof or floor presses against them.

But there is no need to go on a space voyage in order to experience that weightless feeling. It can be felt for a few seconds during a dive, while on the way to the water, or when jumping down to the ground from above. No resistance is felt because the resistance of the air is negligible. It is also negligible at the start of a delayed drop by a parachutist, but only for the first second or two, because air resistance builds up as the drop becomes faster, until when it reaches about 120 m.p.h. the air resistance is equal to the parachutist's own weight, whereupon he feels his full weight once more.

As we all know, we experience a falling sensation when falling; this is because we are momentarily weightless. Consequently, it has been assumed that, since we shall be weightless throughout almost the whole of a space voyage, this falling sensation will be prolonged for days on the way to the Moon or for months on the way to a

planet. Is this true? And, if it is, will the sensation be tolerable if it continues for such a long time? And if the occupants of the spaceship have no sense of the direction in which gravity is pulling, will they become so disorientated as to be unable to navigate the ship?

We shall not know the answer to these questions until human space travel begins; yet the answer is of such importance for the future of astronautics that a great amount of thought, argument and experiment has been undertaken merely to enable us to make an intelligent guess as to what the answer may be.

The logical way to tackle the question is to consider, first, by what various means the body senses gravitational pull, and secondly, what to expect if it is deprived of each of these means in turn and then of all of them together. Here are the chief means by which the body knows which way gravity is pulling:

1. Vision.
2. Bodily sensations, subdivided into—
   (*a*) pressure on the skin where it takes the weight;
   (*b*) tension of the muscles used in balancing;
   (*c*) pressure of internal tissues on each other due to weight.
3. Balancing organs in the inner ear.

1. Vision is a matter of experience; we are used to seeing certain things upright, such as walls, and others horizontal, such as the horizon. The eyes have no inborn ability to sense the direction of gravitational pull; yet, when they have trained themselves, we allow them to override our other senses.

This is especially evident in aviation. The first time the writer broke a glider was in trying to land on an uphill slope; the visual horizon was above the true horizon, so the machine's nose was unwittingly kept too high and it stalled six feet up. When flying blind in clouds, with the eyes unable to help in orientating, a pilot can still keep upright for a time by means of his other sensations. But, sooner or later, turbulence is encountered and gravity is masked by other accelerations; whereupon the pilot becomes disorientated and loses control. The remedy is to train the eyes to use blind-flying instruments, when once more they resume their rôle in overriding all other means of sensing gravity.

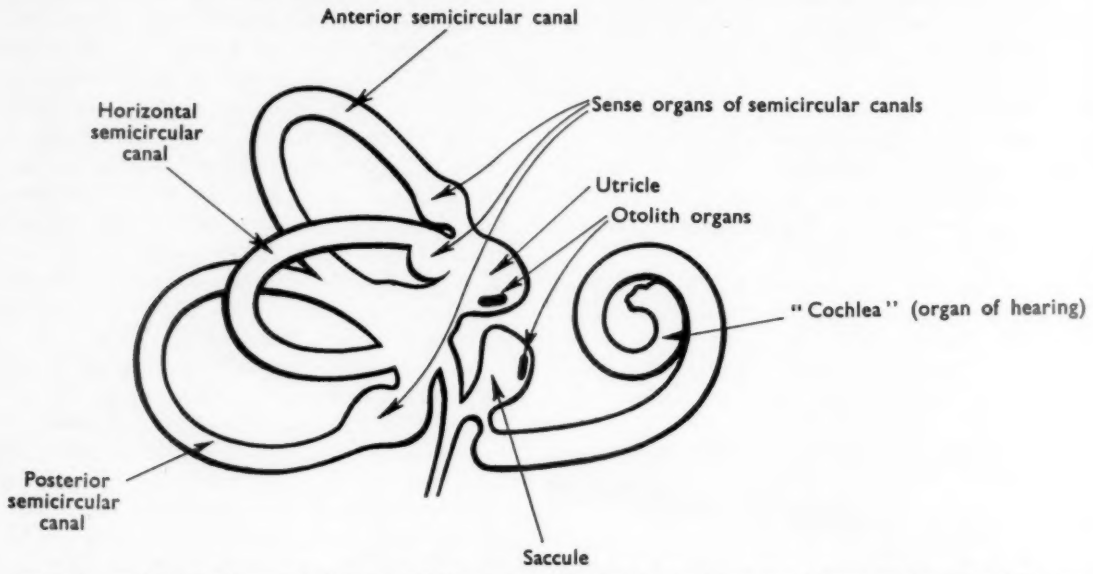


FIG. 1. Enlarged schematic diagram of the group of organs in the inner ear, known as the "labyrinth" or "vestibular apparatus". It includes two kinds of balancing organs: the semicircular canals, which register angular accelerations, and the otolith organs (contained in the utricle and saccule) which register linear accelerations and the direction of gravitational pull, and are believed to play an important rôle in any untoward symptoms during weightlessness

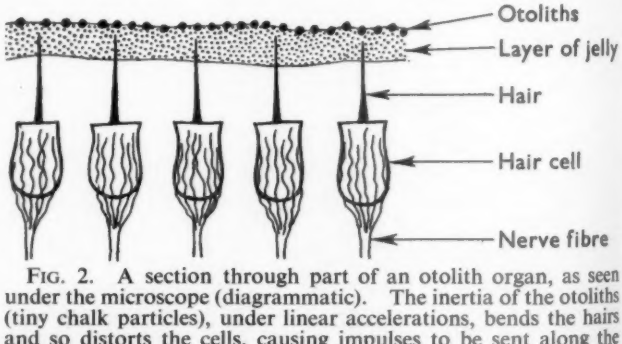


FIG. 2. A section through part of an otolith organ, as seen under the microscope (diagrammatic). The inertia of the otoliths (tiny chalk particles), under linear accelerations, bends the hairs and so distorts the cells, causing impulses to be sent along the nerves to the brain

So we are entitled to some hope that, if the eyes of a space traveller can be given familiar things like a floor, a ceiling and walls to look at, they can be trained to override the other sensations and he can eventually feel comfortable though weightless. But how long will the training take?

2. Bodily sensations play an important part in helping the body to balance itself, but it can be easily shown that

they are not essential for comfort. We can be quite comfortable in water, either swimming or floating, without feeling that any part of our skin is being pressed upon, or that our muscles are exercising any balancing function.

Sensations of our internal organs and tissues weighing upon each other are mostly conveyed by certain sense organs called "Pacinian corpuscles", and some writers on weightlessness have made quite a fuss about these. They are just big enough to be seen with the eye, and if a section through one is examined with a microscope, it looks very like the inside of an onion, but with a nerve-ending in the middle. Evidently, if the layers of the "onion" are distorted by pressure, the nerve registers what is happening.

But it is absurd to suggest that anyone could be upset by his internal organs ceasing to be pulled by gravity in any particular direction. He can comfortably lie on his back, stomach or side, or stand up, yet whenever he changes from one of these positions to another, gravity ceases to pull in the direction it was pulling in before. When the same thing happens at the onset of weightlessness, why should any more harm result?

3. The outer ear passage is separated by a membrane (the ear drum) from a cavity called the "middle ear", and that in turn is separated by another membrane from the "inner ear". The inner ear contains an organ of hearing (the cochlea), a set of "semicircular canals" for sensing changes in the rate of rotation of the head, and the "otolith organs" for sensing accelerations along one particular direction. These organs are joined to each other by tubes of various shapes which together are appropriately called the "labyrinth"; and another name often found in the technical literature is "vestibular apparatus", meaning all the organs of the inner ear together.

We are concerned particularly with the otolith organs, which register changes in the rate of displacement along a line, i.e., linear accelerations. The reason is that gravity has the effect of a linear acceleration when it is being resisted; hence the otolith organs register the pull of gravity.

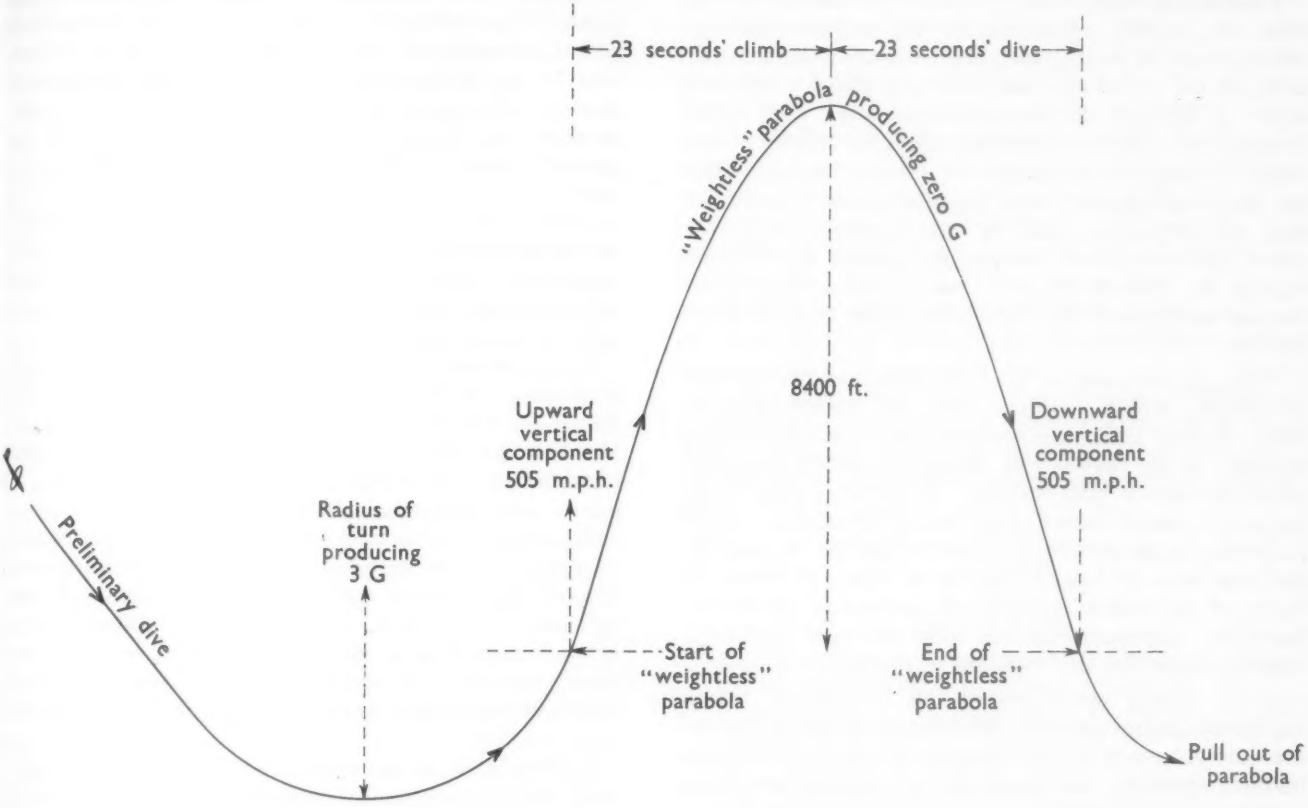


FIG. 3. An example of a "weightless" parabola, during which the sensations expected during a space voyage can be reproduced for a large fraction of a minute

How do they do this? The answer can be seen through a microscope. An otolith organ is spread over one wall of a small cavity bathed in fluid, and consists of several layers. The outer layer contains tiny chalk particles called "otoliths" (ear-stones), embedded in a jelly. Projecting into the jelly are many small hairs with their tips close to the otoliths. The hairs stick out from a layer of cells which forms the base of the organ—one hair sprouts from each cell. Finally, each cell is surrounded by the subdivisions of a nerve fibre.

On any sudden movement of the head, the otolith particles lag behind because of their inertia; their displacement bends the hairs, this distorts the cells from

which they spring, and the nerves register what is happening. The pull of gravity, also, displaces the otoliths from the positions they would otherwise occupy; and this displacement varies according to whether the head is upright, or lying on one side, or bent forwards or backwards, or upside-down. But during weightlessness, such as when falling, the otoliths fall at the same speed as the rest of the body, so they are not displaced either upwards or downwards—nor would they be displaced during the weightless period of a space voyage.

Experiments with animals have shown that the nerves from the otolith organs register the greatest stimulus when gravity is pulling the otoliths away from the hair cells, or else when they are sliding parallel to the cell layer—it depends on the particular nerve fibre being investigated. But the minimum stimulus usually comes when the pull on the otoliths is towards the hair cells. But what will happen when the otoliths have no weight and are not being pulled in any direction? Will the nerves still register the minimum stimulus, or will they register no stimulus at all? We do not know yet, so we had better work out the consequences of both alternatives.

Now, on each side of the head there are two cavities containing otolith organs. One, the utricle, has its layer of hair cells, otoliths and jelly on the bottom surface; so its nerves will register minimum stimulus when the head is held upright. The other cavity is the saccule; it has its otolith organ on the inner wall. Consequently, to get minimum stimulus from the left saccule, the head must be tipped over to the right, to bring the layers of the otolith organ to the bottom of the cavity. Similarly, minimum stimulus from the right saccule is received when the head is tilted to the left.

So if, during weightlessness, all our otolith organs register minimum stimulus, their nerves will tell us that we are simultaneously upright, lying on our left side and lying on our right side. The result can only be disorientation.

On the other hand, if no stimulus is received during weightlessness, then that is what happens when we are falling, and the absence of stimulus from the otolith organs must be responsible for that falling sensation.

The foregoing set of arguments, which were developed by the writer in an earlier paper,[1] together with some others (e.g., by H. Haber and S. J. Gerathewohl),[2] represent just about as far as we can get towards solving the problem of weightlessness by theorizing alone. But recently, with the increasing speeds of aircraft, it has been possible to prolong the weightless condition beyond the very few seconds formerly available, up to a substantial fraction of a minute. This is still nothing like the duration of even the shortest space voyage, but nevertheless enough practice has been added to theory to produce some useful lessons.

The technique is to make the aircraft follow the same path (in space *and* time) as would be traced by a missile in a vacuum, i.e., a parabola, meanwhile using just enough engine power to nullify the effect of air resistance.

Among the first to try this manœuvre for the purpose was Professor H. von Diringshofen,[3] whose technique was to pull the machine's nose up suddenly, stall, and then go into a vertical dive with the engine on. He managed to make himself weightless for 8 to 10 seconds, and said that he found the experience, which he repeated many times, "agreeable" (*angenehm*).

Major E. R. Ballinger, of the Aero Medical Laboratory of the Wright Air Development Centre at Dayton, Ohio, tried some experiments in 1951 with a jet-engined F-80 E aeroplane.[4] He states that he pulled it up into a vertical climb at about 600 m.p.h., and that this gave a weightless period averaging 15 seconds, with a maximum of just over 20 seconds (though actually a vertical component of only 440 m.p.h. at the start of the climb would produce this duration on the ascending leg of the parabola alone). Thirty runs were made with a passenger, and he reported that they "gave no suggestion of motion sickness, vertigo or incoordination attributable to weightlessness". But he says, significantly, that orientation could be maintained with moderate effort only as long as he was held in place by a belt and had a point of visual reference.

In Argentina Dr. H. von Beckh[5] has experimented with both men and animals. His aeroplane used only the downward leg of the parabola to obtain weightlessness. His passengers had to draw, with their unsupported right hand, a series of crosses diagonally across a square of paper on a stiff base held in the left hand. During weightlessness, with eyes closed, the passenger would start from the left top corner drawing his line of crosses towards the opposite corner, but then suddenly deviate upwards to the right; evidently his arm muscles were trying to compensate for the non-existent weight of the arm. But they all performed better when their seat belts were tight than when loose, and they all improved with practice.

In the animal experiments, von Beckh used some small river turtles. These turtles were voracious and would dart out their heads accurately at any bit of food offered them. But one turtle, after becoming overheated due to failure of a thermostat, was unable to guide its head to the food, and von Beckh concluded that it had lost the use of its balancing organs in the inner ear; but after a fortnight it had trained itself to use its eyes alone.

Then the turtles were all taken up in a tank for a flight and offered food during the weightless dive. Whereupon the turtle which had learned to do without its balancing organs seized its food with perfect aim, but now it was the turn of the others to shoot out their heads all round the target instead of at it. The obvious lesson is that disorientation was due to the wrong functioning of the otolith organs during weightlessness, but that the eyes can be trained to take over their orientating functions, though the training takes over a fortnight. Cats and apes, by the way, if their balancing organs are destroyed, take only a few days to recover their orientation. But even that is too long a period for humans if it has to be done after a space journey has started.

Similar results were found in the famous experiments with mice sent up in rockets and photographed during the weightless period. The first mouse went up alone in a wedge-shaped chamber contained in a V-2 rocket; it was killed on landing, but according to the film, which was recovered, it had shown no sign of confusion before its death.

Then Aerobee rockets were used. After an experiment which went wrong, two mice were taken up in the second Aerobee, enclosed in a rotating transparent drum, and again photographed. One of the mice had had its balancing organs in the inner ear destroyed, and lay comfortably during the weightless period, apparently holding on to a tiny crack. The other mouse, with balancing organs intact, clawed about wildly.

In one more experiment, two normal mice were used, but one mouse was given a shelf and hung on to it comfortably, while the other, with no shelf, clawed about and wriggled as before.

Back to the human species, but still using rocket propulsion, we have the recent series of flights to 90,000 feet and more, by rocket-propelled aircraft, in which there can be a practically weightless period of half a minute after the motor is cut out during the ascent. Major Charles Yeager, who pioneered the first flights of this kind, does not sound too hopeful. According to report, "after 8 to 10 seconds he felt his head grow thick, and the first disturbances of orientation set in. In his thirteenth second of weightlessness he got the impression that he was spinning around slowly in no particularly defined direction. After 15 seconds he became lost in space, and he pulled out of the parabola".

So far, therefore, aircraft and rocket flights have established that any disorientation and other unpleasant sensations are probably due to the active functioning of the otolith organs. But on the question whether such sensations can be tolerated, different pilots tell different stories.

However, the latest experiments to be published have done much to clear up doubts. The technique of flying the full parabola—both the upward and downward arcs—was worked out by F. and H. Haber.[7] Using this technique on behalf of the U.S. Air Force School of Aviation Medicine, S. J. Gerathewohl[8] tried out 16 passengers in turn, in about 200 flights with the same pilot flying every time. All had had flying experience. The aircraft was a Lockheed T-33A, and made either a dive from about 20,000 feet, or, after a preliminary dive to gather speed, was pulled up into a parabola. The periods of weightlessness lasted between 10 and 30 seconds.

He found that eight of the subjects liked the sensation, three were indifferent to it, and five found it unpleasant and suffered from motion sickness. One of the first group wrote afterwards:—"The weightless condition brought on an extreme feeling of well-being and comfort. At no time did I have the sensation of falling. The sensation of lack of physical support was also strangely missing. It was what I would suppose suspended animation might feel like. All my internal organs were comfortable, and I maintained normal mental activity. As the period of weightlessness lengthened I could feel my body relaxing. Actually, I've never been so b—— comfortable in all my life; and I think that if I had my choice of places to relax, a weightless condition would be definitely it."

So there we are. The answer to the problem of weightlessness, so far, is that it depends on who is being made weightless. But what would happen for longer—much longer—periods than 30 seconds remains a problem still.

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Preliminary Report on Observations of Mars Made at Mount Wilson in 1956

By ROBERT S. RICHARDSON

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On September 7, 1956, Mars came within 35,131,000 miles of the Earth, the closest approach since 1924, and the closest the planet will come again till 1971. The 60-inch and 100-inch telescopes on Mount Wilson were used to observe Mars for 34 nights from May 5 to December 16, 1956, for a total of 110 hours of actual observation. Observing conditions during this time were generally favourable.

Observations of the Canals.—Such an exceptionally close approach of Mars would seem to furnish a fine opportunity for studying the canals. But the visibility of the canals depends upon other factors besides distance. Experienced observers agree that the visibility of the canals depends rather critically upon the season in the southern hemisphere of Mars. Thus the canals first appear satisfactorily when the date in the southern hemisphere corresponds to about April 1 in the United States, and by the middle of Martian June little is left of them. In 1956 south Martian April 1 came on May 23, when the planet was still 82 million miles away. And when Mars was closest in September the Martian date was about June 10. Hence, the opportunity for studying the canals in 1956 was not as favourable as might be supposed.

My first photographs of Mars were taken on June 3 at the 60-inch telescope under very favourable conditions. The season in the southern hemisphere of Mars then was about April 8. The disk of the planet had a peculiar aspect which puzzled me at first. It was covered with what appeared to be innumerable blue veins extending across the bright red regions. It was some time before it occurred to me that these must be canals. I was taken completely by surprise as it had never occurred to me that the canals might be visible at a distance of 75 million miles. Although some good photographs of Mars were secured that night, the images, about one-tenth of an inch in diameter, were too small to show the fine markings that were readily visible to the eye under high magnification.

The only other time I clearly saw canals was on October 10 at the 100-inch telescope, when the far southern canals *Simois* and *Thermadon* were distinctly seen as dark straggly streaks.

Photographs of Mars in yellow light about 5/16th of an inch in diameter taken on August 10 show the canals Gehon, Hiddekel, Cantabras, Agathodæmon, Ganges, Nectar, Nilokeras, Draco, and Jamuna. They show on the negatives as light wispy streaks. From these photographs and my visual observations I am convinced of the existence on Mars of streaks at the approximate position of well-known canals. They convey to me the impression of being some natural surface feature.

Colour of the Dark Regions ("*Maria*").—The dark regions on Mars or "maria" were examined for colour whenever observations could be made. The colour of the maria is of considerable interest since these regions may possibly consist of vegetation. From June 3 to September 13 the maria always appeared to me as slate blue. This was the opinion of other observers who happened to be nearby. But when the maria were examined on October 10 they appeared to me as light green. No blue tint was evident. They also appeared as grey-green when last observed on December 16, 1956.

Carbon Dioxide in the Atmosphere of Mars.—G. P. Kuiper has discovered two bands in the far infra-red spectrum of Mars which he attributes to carbon dioxide gas (CO_2) in the planet's atmosphere. (Carbon dioxide is the gas that comes bubbling out of a whisky and soda.) The concentration of carbon dioxide has been estimated as fifty times that in the Earth's atmosphere. This seemed so high that Dr. Edison Pettit (retired) urged me to search for the carbon dioxide band in the near infra-red at wavelength 7820 A. This is often called the "Venusian" carbon dioxide band since it was first discovered in the spectrum of Venus in 1932. It does not show in the spectrum of the Earth's atmosphere.

Spectra of Mars taken at the 100-inch telescope failed to show a trace of the 7820A band of carbon dioxide. The absence of this band should enable us to set an upper limit for the amount of CO_2 in the Martian atmosphere. This limit is unknown today. Its determination will be a laboratory job.

Water Vapour in the Martian Atmosphere.—Spectra of Mars show water vapour lines extending across the polar cap, maria, and deserts. We would expect to find more moisture over the polar caps and maria than the deserts. This would be indicated by the greater strength of the water vapour lines over these areas. But examinations of the lines shows no significant variations in strength that can be attributed to water vapour.

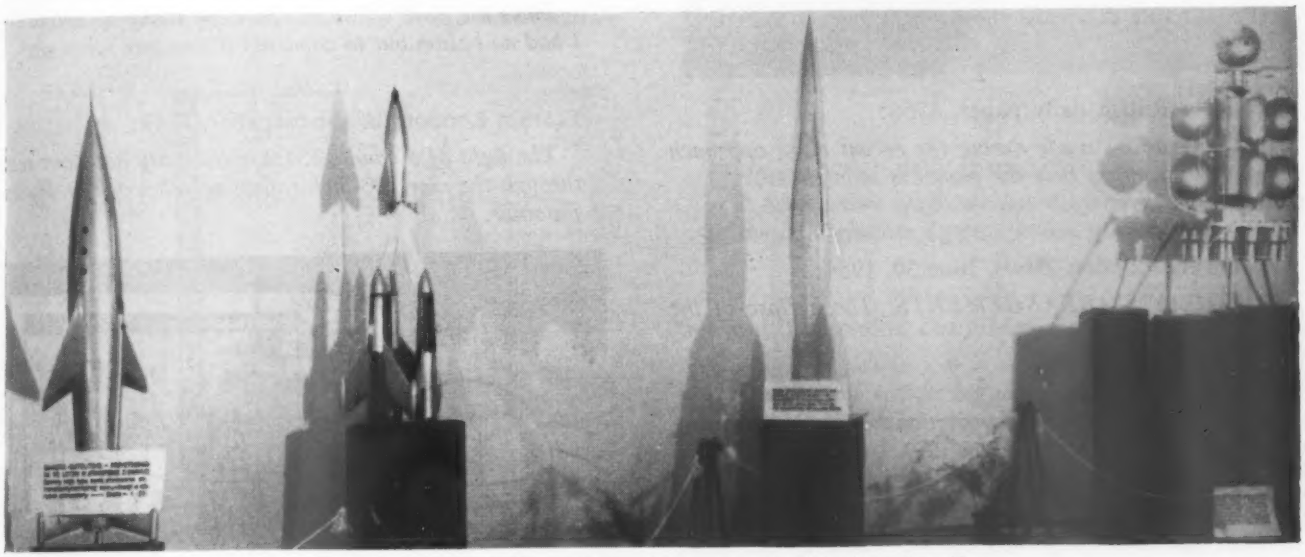
Oxygen in the Atmosphere of Mars.—It seems doubtful if there is enough oxygen in the atmosphere of Mars to be detected by the method of velocity shifts, the most sensitive test known at present. It seems desirable to try some entirely new technique, as for example rocket spectra of the red oxygen bands in the Moon and Mars taken above 65 miles, where molecules of oxygen supposedly no longer exist in the Earth's atmosphere.

The First Polish Astronautical Exhibition

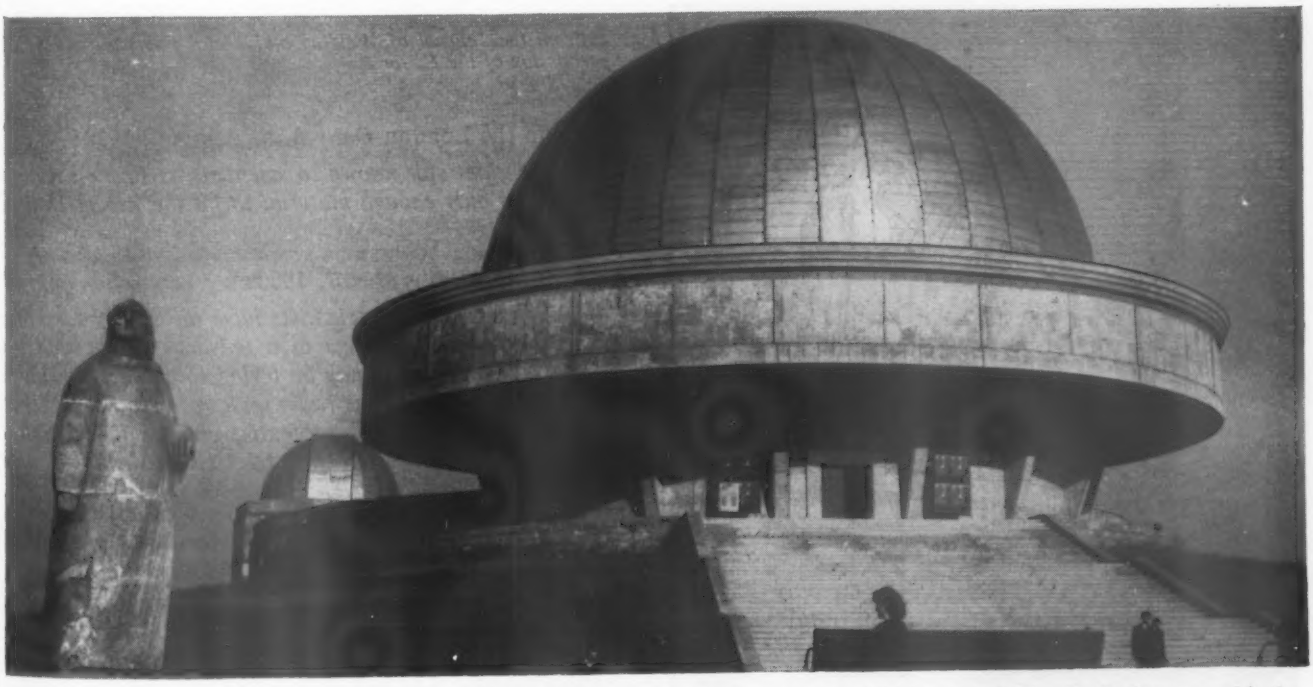
Ing. Wladyslaw Geisler has sent us some most interesting photographs of the first Polish Astronautical Exhibition, organized by the Silesian branch of the Polish Astronautical Society together with the Science Technical Museum N.O.T. of Warsaw, at the Silesian Planetarium, Katowice, between October 1 and December 1956.

By means of over 300 photographic enlargements, models and documents, the exhibition portrayed the past, present and future development of astronautics. Rocket motors and components of German war rockets were exhibited, as well as Polish developments. Up to November 19 the exhibition had been visited by over 25,000 people, including delegations from the United States, Russia, China, Indonesia, Denmark, Sweden, Hungary, Yugoslavia, Czechoslovakia and Germany.

The Polish Society must be congratulated upon producing what was clearly a most successful exhibition.



In the exhibition hall: rocket models on a scale of 1:20 and 1:40



The buildings of the Silesian planetarium in Katowice, where the Astronautical Exhibition was held. In the foreground is the Copernicus Memorial

"It was in the Papers"

By W. JOHNSON

1

From an Australian daily paper, 1938:

It has now been established that the white polecats of Mars are made of ice or snow.

(Presumably the word should have been polecaps!)

2

From a British daily paper, 1956:

Observations made during the recent close approach of Mars confirm that the planet is uninhibited.

3

From the London *Times*, June 30, 1954:

TODAY'S ARRANGEMENTS: The Eclipse of the Sun.

4

Profound statement by a writer named S. D. Sampson, made in a New York paper in 1953:

The principles laid down by Albert Einstein show that the idea of conquering space is but a fantastic dream. This has been confirmed by the work of Sir Isaac Newton.

5

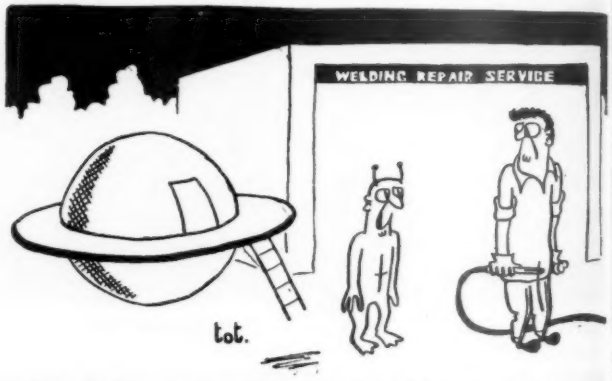
Even more profound statement made in 1955 by a Dr. H. C. King, writing in the *Journal of the British Astronomical Association* about a book on space travel:

Since the book outwardly bore the stamp of authority, I had no option but to condemn it.

6

From a London daily newspaper, 1949:

The light of a candle 1,000 *miles away has been seen through the new* 200-*inch reflecting telescope at Mount Palomar.*



From the Journal of Welding and Metal Fabrication, by kind permission of the Editor

7

From the London *Daily Mail*, January, 1938:

The giant star known to scientists as Epsilon Auriga contains only enough material to fill the Albert Hall.

8

From the *Daily Mirror*, 1950:

Eighteen puzzled scientists have an uneasy idea that some mysterious beings in a universe far beyond the range of telescopes may be trying to contact the Earth by radio. For strange radio waves are regularly picked up and recorded by automatic, electrically-controlled "pens" at Manchester University Experimental Station at Jodrell Bank, Cheshire.

9

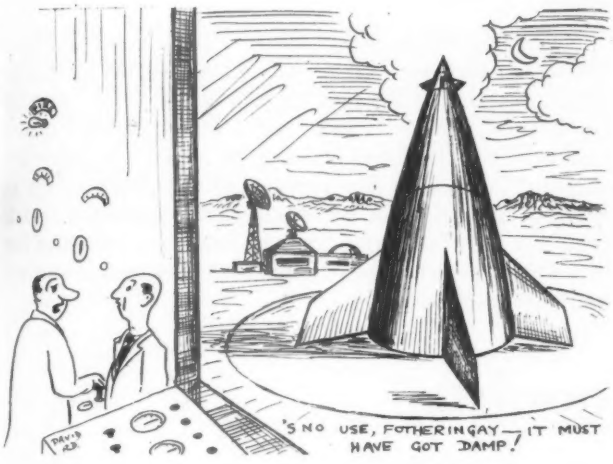
From a local paper, July 1, 1954:

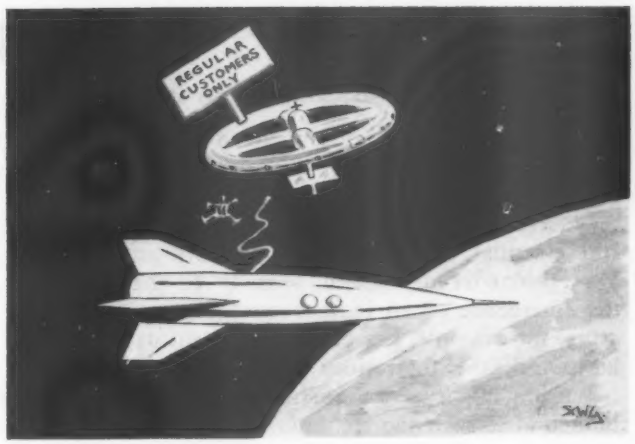
Local residents were disappointed not to be able to see the solar eclipse which occurred yesterday. Mr. F. G. White, an amateur astronomer, believes that this was because the sky was overcast while the eclipse was in progress.

10

From the London *Daily Telegraph*, February 28, 1951:

The U.S. Naval Observatory has reported the chance discovery of a celestial body, thought to be a minor planet, about 20 deg. west of the zenith of the Pleiades. Dr. William Markowitz discovered it when a 26 in. reflecting telescope was trained on the Pleiades. It is so bright that he is surprised it has remained undiscovered for so long. Experts believe it is probably a large asteroid, although it is travelling at 3 times the normal speed of these minor planets. Americans who believe in flying saucers are excited by the idea that the object may be a spaceship launched from a planet outside the solar system.





11

From a London daily paper, 1938:

A Roumanian professor has discovered a new planet in the constellation Lynx. It has a small tail.

12

From the London *Daily Mail*, January 30, 1953:

While the Moon was in eclipse last night, the shyest star in the sky had its big night out. Practically every astronomical telescope in Europe was trying to follow the movement of NZC 1327, a star so small that it can never be seen with the naked eye. It can be watched with a powerful telescope only during an eclipse of the Moon. . . .

China's Young Space Fans

Astronautics has found its way into *China Pictorial*, a lavishly produced magazine covering all aspects of life on the Chinese mainland. In the November, 1956, issue a double-page spread illustrates some of the results of an "international art contest for children", organized by the Belgrade Radio Station, the subject being "Journey to the Moon".

Twenty-nine pupils of Peking secondary school won the "collective award, first class", and seven of their winning pictures are shown in colour; whether each one is the result of "collective" effort is not stated, but they are extraordinarily good for a children's effort, especially in composition.

First we see two rockets taking off at "22.00 hours sharp" on May 28, 1975, from Peking, bearing a cargo of children who have been invited to the "June 1 International Children's Day festivities on the Moon". Next we see them on the journey, with one small boy floating freely in the cabin air because he "forgets to keep his feet in the floor rings". But, though the children have done the pictures, the captions describing them have evidently been written by some ignorant grown-up, who says of this picture: "We've done 15 hours' smooth flight and have long outreached the sphere of the earth's gravitational pull." On the Moon, stars shine in the daytime, and everybody wears a space helmet and carries oxygen cylinders, except for the crowds inside an immense transparent dome, where a sports meeting is held in which the basket-ball posts are immensely high and "boxers soar through the air". Finally, the party lands back at Peking and is welcomed with "flowers, songs and dances".

A. E. SLATER.

Correspondence

A New Twist to an Old Problem

Sir,—Ever since the widespread adoption of the metric system outside the English-speaking countries, attempts have been made to abolish ounces and feet and miles; they have had little success and the conversion tables are still essential equipment for engineers and scientists. Very recent trends, indeed, seem to go the other way: the emergence of an indigenous Indian scientific literature, for example, has begun to present us with crores, lakhs and other mysterious units.

But one might have thought that a comparatively new branch of science and technology, such as that of rocket engineering, which uses good brains quite irrespective of nationality, would have standardized its units from the outset. Even a cursory glance at some of its terms shows that this is not so. Taking, for instance, the "specific impulse", Mr. Hurden tells us that it represents the thrust produced by burning one pound of propellants per second. Are we to believe that German, French or Russian rocket engineers calculate the specific impulse in terms of 0·4536 kg./sec.? Or do we have to start that business of converting lb./sq. in. into kg./cm.^{2} all over again?

Surely it is early enough to avoid confusion at least in this field, even if other old-established units are now hard to replace. Cannot some authoritative body in the field of rocket engineering take the opportunity of the I.G.Y. to standardize units before it is too late?

Yours, etc.,

Ian S. Menzies.

42, Longmarsh View,
Sutton-at-Hone, Kent.

January 3, 1957.

P.S.—Since writing the above, I have come across a preview of the third full-scale Commonwealth Standards Conference in Delhi, opening on January 21. One of the general subjects under discussion is called "metric and inch" problems and is said to be a specially important subject "because of the decision of the Government of India to change, over the next ten years, to the metric system". Whilst I apologize to India for accusing her of adding to the confusion, this news only reinforces my main argument.

Our Cartoonists

S. W. Greenwood. Born in 1924; joined the British Interplanetary Society in 1946. Mr. Greenwood is now a member of the Council, and is particularly known in the West Country, since he helped to found the Western Branch in 1952. He has a B.Sc.(Eng.) from the University of Bristol and an M.Eng. from the McGill University, Montreal. He lectures on ramjets and gas dynamics at the College of Aeronautics, Cranfield.

R. F. Chapman. Born in 1935, in London; joined the Society in 1952. After leaving school, he entered a commercial art studio for a five-year apprenticeship; at present he is undergoing National Service in the R.A.F. Other hobbies: modern art, modern music and motorcycling.

David A. Hardy (= David RD). Born in 1936; joined the Society in 1952, though his interest in astronomy dated back to his boyhood. He is best known in the Midland Branch, where he provides many paintings for exhibitions. He prefers serious painting to cartooning, and is also interested in photography.

Mr. Hardy states that this photograph was taken some years ago, but he will not reveal just *where* it was taken. The Editor refuses to speculate!

S. W. Greenwood

R. F. Chapman

David A. Hardy

University Lecture Course on Space Travel

Manchester University took a pioneer step early in January when its extra-mural department announced a course of seven weekly public lectures on space travel, to commence in the middle of the month. The programme began with a review of popular science fiction, showing how often it is based on facts. Mr. J. Ring, lecturer in physics, followed this with lectures on interplanetary navigation, after which the series included lectures by an astronomer, Dr. F. D. Kahn; an aerodynamicist, Dr. J. H. Gerard; a zoologist, Mr. J. G. Blower; and another astronomer, Professor Z. Kopal. Mr. Ring was also booked for a final lecture on "What do we do when we get there?"

A. E. SLATER.

The Birth of Space Law?

On January 14 Mr. Cabot Lodge, United States delegate to the United Nations, put forward a disarmament plan to the political committee of the General Assembly which included a provision for putting space vehicles under international control. In the words of *The Times* United Nations Correspondent:—

The United States proposed that the first step towards the objective of assuring that future developments in outer space would be devoted exclusively to peaceful and scientific purposes should be to bring the testing of the objects known as "earth satellites", "inter-continental missiles", "long-range unmanned weapons", and "space platforms" under international inspection and participation.

The American earth satellite planned for the International Geophysical Year was an example of an open project devoted exclusively to scientific purposes and developed with the knowledge and approbation of the scientists of the nations represented in the International Geophysical Year.

How to Increase "G" Tolerance

A method of increasing human tolerance to high accelerations at the take-off of a rocket is described in the *Journal of Aviation Medicine* (U.S.A.).[1] A team of workers at the U.S. Air Force Aero Medical Laboratory has found that tolerance is greatly improved if the acceleration is built up gradually at the rate of 15 seconds per *g* unit (*g* being equal to the acceleration caused by gravity, so that, for instance, a body subjected to 5 *g* acquires, in effect, 5 times its normal weight).

Their experiments were conducted with a centrifuge in which the subject is spun round at the end of a long arm, so that the acceleration in this case is due to centrifugal force, not to a rocket motor. By the conventional method of applying the acceleration suddenly (actually building it up at 1 *g* per second), it was found that "blackout" of vision occurred on the average when 3·7 *g* was reached. But by using the technique of "gradual onset", an average of 5·6 *g* was needed to cause blackout, so that an increased tolerance of 1·9 *g* was attained. But this was only an average; in individual subjects (32 were tested) the improvement varied between 0·4 and 3·5 *g*—a very large range.

The subjects were also tried with "*g*-suits", which compress the lower half of the body and thus prevent blood from draining away into the abdomen and legs owing to its increased weight. Wearing a suit was found to give an increased tolerance of 1·6 *g* on the average, but this, again, varied much with individuals. Curiously enough, those who benefited most from *g*-suits were usually the same people who also benefited most from the "gradual onset" technique, which seems to show that the effect of the suit is not purely mechanical but varies with the ability of the body to compensate for increased *g*. This compensation is believed to consist mainly of a constriction of the arteries, thus raising the blood pressure and consequently enabling a "heavier" column of blood to be supported over the vertical distance from the heart to the brain.

The authors are concerned only with aviation, for which the lesson appears to be that you can safely make tighter turns the longer you take in tightening them. But what is the lesson for space flight? It appears to be that, if you want to save fuel by increasing the acceleration with which your ship leaves the Earth, you must use additional fuel in order to build up the acceleration more gradually. It is for the technicians to work out the balance between these two factors.

A. E. SLATER.

REFERENCE

[1]R. Edelberg, J. P. Henry, J. A. Maciolek, E. W. Salzman and G. D. Zuidema, "Comparison of Human Tolerance to Accelerations of Slow and Rapid Onset", *J. of Aviation Medicine*, December, 1956, **27**, 482.

Sky Diary: April to June 1957

By GEOFFREY TURNER, F.R.A.S.

At the beginning of the seventeenth century, it was not generally accepted that the Solar System consisted of planets travelling around the Sun and satellites travelling around the planets. Galileo's discovery of the four large satellites of Jupiter was, therefore, unexpected. The satellites are not difficult objects to observe; in fact, they can be seen in binoculars of quite low power, and some people can even see them with the naked eye, although this is unusual since all four moons are very close to the planet and are thus lost in its glare. Altogether Jupiter has twelve known satellites, but only the four brighter "Galilean" satellites—named after their discoverer—can be seen through small or medium-sized telescopes. Unlike the Moon, the Galilean satellites travel round the planet in quite short periods from 40 hours to 16½ days. They are interesting to watch from night to night to see the changes in their positions. The plane of their their orbits is such that they can be seen crossing the face of the planet with their shadows; also, they can be occulted by the planet or eclipsed by its shadow. Tables of the satellite phenomena are given in several handbooks and almanacs.

The reason for this description of Jupiter's satellites is that this planet is now favourably placed for observation. During the three months in question it will be on the borders of Leo and Virgo.

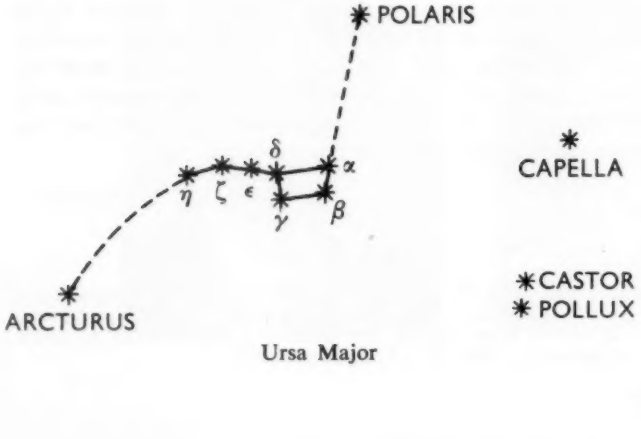
At the beginning of April, the planet Saturn rises just before midnight, and by the end of May it rises before sunset. It is very poorly placed for observation in the latitude of England this year, since its altitude is very low. Saturn will be the second brightest object in the night sky, having a magnitude of 0·6 in April and gradually brightening to 0·2 at the end of June. Jupiter will, however, be much brighter at about −1·9. Although Saturn has nine satellites, they are not as spectacular as those of Jupiter, although some of them can be seen in a three-inch telescope in favourable conditions. Saturn is in the constellation of Ophiuchus at this time.

On the night of May 11 and the morning of the 12th, there will be a total eclipse of the Moon. The Moon enters the penumbra at 7.42 p.m. and the umbra at 8.45 p.m. Total eclipse begins at 9.52 and ends at 11.10. The Moon leaves the umbra at 12.17 and the penumbra at 1.20 a.m.

During these months one of the most prominent and best known constellations, Ursa Major—The Great Bear, or Plough as it is better known—is almost overhead in the evening. Although this constellation covers a large area of sky, it is better known by the seven bright stars which give it its characteristic shape. Although the stars of a constellation are given designations of Greek letters, α being the most prominent, β the next and so on, most of the brighter stars have been given names. The stars of Ursa Major are given in the list, together with their proper names and brightness; they are also shown on the diagram in relation to the other bright stars and interesting objects in the vicinity.

The Pole Star, Polaris, can easily be found by tracing an imaginary line from β through α and outwards; the first bright star which it intersects is Polaris. For this reason, these two stars are often called "The Pointers". If the Pole Star is examined through a telescope, it will be found to have a faint companion which is slightly bluish in colour; for this reason, it is known as a double star. There is also a famous double star in Ursa Major; Mizar has a fainter companion called Alcor, easily visible without a telescope. A small instrument shows that Mizar is itself double.

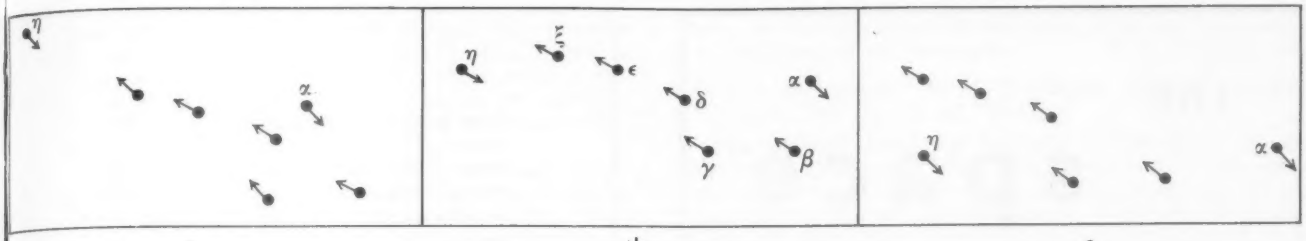
Polaris is called the Pole Star because it is near to the North Celestial Pole. The position of the Celestial Pole is not fixed; it wanders very slowly, and will be at its nearest to Polaris in the year A.D. 2095. Another interesting point about the movement of stars, known as their proper motions, is that five of the stars in Ursa Major all travel in the same direction and thus seem to be associated with each other, but the other two seem to be going in the opposite direction. Because of the proper



Ursa Major

THE MAIN STARS OF URSA MAJOR

Star	Magnitude
α Dubhe	1·9
β Merak,	2·4
γ Phecda	2·5
δ Megrez	3·4
ε Alioth	1·7
ζ Mizar	2·3
η Benetnasch (or Alkaid)	1·9



a
200,000 B.C.

b
1957 A.D.

c
200,000 A.D.

Proper Motions of the Chief Stars in Ursa Major

motions, which are so slight that they can hardly be noticed over many centuries, the constellations change their shape. The diagram shows the directions in which the stars of Ursa Major are moving, and their relative positions 20,000 years ago and 20,000 years hence.

There are two interesting objects, visible to the unaided eye, well placed during this period. They are Coma Berenices and Præsepe; the former is so open that it is a constellation in itself, but Præsepe is a cluster so compact that it appears as a fuzzy patch. Even a casual glance at these clusters with a simple opera glass will show that they consist of very many stars; in fact, for such objects as these, a pair of binoculars with a wide field gives a better view than a very powerful telescope which usually has a very restricted field, so even the simplest aids should not be despised.

Reviews

Men, Rockets and Space. By Lloyd Mallan. Cassell and Company Ltd., 1956. 298 pp. Price 18s.

The title of this work, coupled with the rocket motif of its multi-coloured jacket, is somewhat misleading. Here, it would seem, is yet another discourse on interplanetary travel and its prospects. But here, it transpires, is nothing of the sort, for *Men, Rockets and Space* is concerned not so much with the possibilities of the future, as with the harsh realities of the present, in the guise of linear deceleration devices, giant centrifuges, decompression chambers, trans-sonic rocket planes, and spaceship simulators—with particular reference to those who take the calculated risks which are involved in manning them. The result is a vivid and highly informative account of contemporary American endeavour, made all the more impressive by the fact that there is no serious attempt to distract the reader's attention by a recapitulation of the now familiar history of the development of the rocket motor (though due deference is paid to the pioneer activities of Goddard, whose work at Roswell, New Mexico, we are asked to believe, provided German engineers with the knowledge which enabled them to produce the V2).

The book is profusely illustrated, two of its many excellent photographs depicting aircraft personnel floating freely in mid-air at zero gravity, some 5,000 feet above the Wright Air Development Centre. Of unusual interest, too, is the last of its fourteen chapters, which gives the substance of tape-recorded replies which were obtained by the author from space research engineers, aeromedical men, rocket test pilots, and the like, in answer to the 64,000 dollar question: Is the Moon-or-beyond our goal? Members of the B.I.S., at any rate, will find the answers as encouraging as they are reassuring.

P. E. CLEATOR.

Rocket. By Air Chief Marshal Sir Philip Joubert de la Ferté. Hutchinson, 1957. 190 pp., 15 plates. Price 18s.

In the words of the author: "The contents of this book fall into two categories. The first part is historical and sets out to trace the development of rockets and rocket propulsion to the point where the threat to Britain's security from Hitler's V1 and V2 weapons was brought to nothing by the counter-measures of the Allies. . . . The second part of the book is written in an attempt to analyse the effects, political and military, that long-range rockets carrying atomic or nuclear warheads can have on the policies of those nations that can produce and use them."

The author, now retired, has had a distinguished career in the Royal Air Force. His viewpoint is that of a strategist rather than a scientist, and this work forms an interesting complement to the many books on rocketry written by engineers and scientists. He regards the rocket with nuclear warhead as "the one overwhelming weapon".

His treatment of the history of rocketry up to the development of the V2 is brief indeed. No direct mention is made of the work of Dr. Robert H. Goddard. Future prospects in the civil field and in space flight are also dealt with briefly, though encouragingly. The author's main treatment deals with the work that led to the Allies' discovery during the second world war that Germany was developing unmanned missiles, with the steps taken to limit the seriousness of the threat, and with the present-day significance of "the one overwhelming weapon". The reader learns of the part played by photo-reconnaissance and reports from agents in the uncovering of the German V weapon programme, and of the work of Mr. Duncan Sandys, the present Minister of Defence, in assessing the extent of the threat. The attack on Peenemünde, the main research centre for the weapons, is vividly described from the viewpoint of the attacking force. The author considers that the V weapon programme was probably delayed about six months by this attack and by subsequent attacks on launching sites. He expresses the view that plans for the allied invasion of Europe might have been seriously affected had this not been achieved.

With reference to the present position, he declares that we in Britain "are lagging badly". Our weapon thinking is largely out of date. He makes suggestions for radical changes in British military policy.

The book will be widely studied and deservedly so. While it is difficult to determine the current official British attitude

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★ **PATRICK MOORE, F.R.A.S.,** *author of 'Guide to Moon', etc.*

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EYRE & SPOTTISWOODE

to rocketry and to missiles generally owing to the extensive security blanket, it is probable that this book will serve a valuable purpose in stimulating people in many walks of life to think about the changing military picture, and perhaps shake up those who are inclined to emulate the ostrich when rocketry is mentioned.

The book is generally readable and full of interesting detail. This reviewer found certain aspects rather distracting, however. The history of aerial photography presented in some detail in the second chapter follows rather abruptly on the history of the rocket in the first. The part played by the air-breathing pulse-jet powered V1 weapon in the war understandably takes up a large part of the book, and reference is made to missiles now under development powered by air-breathing ramjet engines. The feature calling for comment here is that the term "rocket" appears at times to be applied rather loosely to missiles powered by air-breathing engines. The distinction is fundamental, and there are points in the text where the distinction is unfortunately not apparent.

In conclusion it should be stated that the photographs and illustrations are generally clear and add to the interest of the text. In the light of present-day book prices, the price asked may be regarded as reasonable. S. W. GREENWOOD.

Guide to the Heavens. By H. P. Wilkins. Frederick Muller, 1956. 107 pp. Price 10s. 6d.

This pleasant little book has been written mainly for the beginner in astronomy who is equipped with a very small telescope or a pair of binoculars. It includes star maps, lunar charts, and notes on the planets. The print and presentation are good, and the book is a good simple introduction to observational astronomy. A. W.

The ABC of Rockets and Space-travel. By M. F. Allward and J. W. R. Taylor. Ian Allen, London, 1956. 64 pp. Price 3s.

An instructive and well-illustrated booklet on the progress in rocket engineering, and current work on the Vanguard project. A simple account of the rocket is given; fuels are described, and a section of the book is devoted to the possibilities and hazards of true space-travel. The illustrations are good, and the booklet makes easy reading. P. J. C.

Other Recent Books

(Mention in this list does not preclude subsequent review.)

World of Space. By M. F. Allward. Collins. 2s. 7d.

The Men Behind the Space Rockets. By Heinz Gartmann. Weidenfeld and Nicholson. 18s.

The Science Book of Space Travel. By H. L. Goodwin. Harrap. 10s. 6d.

The Modern Universe. By R. A. Lyttleton. Hodder & Stoughton. 16s.

Guide to the Moon. By Patrick Moore. (New, revised edition). Collins Comet Books. 2s. 6d.

Introduction to Astronomy. By C. Payne-Gaposchkin. Eyre & Spottiswoode. £2 10s.

Extrapolation to A.D. 2000

At an astronautical congress in Stuttgart last November Dr. Eugen Sänger, head of the Research Institute for the Physics of Reaction Propulsion in that town, demonstrated some graphs he had worked out showing the increase of flying speeds since 1900, with extrapolations into the future as far as the year 2000. Manned aircraft had reached Mach 1 (the speed of sound) by 1947, and Mach 3 by 1956, and Dr. Sänger anticipated that in 1960 six times, and in 1970 28 times the speed of sound would be attained.

But rockets were a different matter. They (or rather the V2) were already travelling at 6 times the speed of sound in 1943, and inter-continental missiles today were reaching 20 times the speed of sound. By the year 2000, Dr. Sänger said (according to *Der Flieger*), it was hoped that rockets would attain the speed of light! He is, as is well known, a leading exponent of the idea of the "photon rocket", which would expel photons at the speed of light; but whether the rocket itself could be regarded as reaching that speed depends on who is observing it, as he explained in a paper given to last year's International Astronautical Congress. To a stationary observer, it could never quite reach such a speed, but the travellers on the rocket, estimating their velocity from the readings of a clock and an accelerometer, could eventually reach many times the speed of light on their own reckoning, provided the fuel held out.

A. E. SLATER.

Observatory for the British Interplanetary Society

Astronomy is of course one of the most vital concerns of any astronautical society, and it is therefore very pleasing to record that the British Interplanetary Society is to have an observatory of its own. This is to be founded by the Yorkshire Branch, and will be situated at Harlow Hill, near Harrogate. The building itself is to be a converted tower.

Work is already in progress, and many of the initial difficulties have been solved by the most generous gift made by Mr. T. S. Lucas.

A full report of the new Observatory will appear in the next issue of *Spaceflight*.

The Spring Melt on Mars

Despite the fact that Mars has only a quarter of the Earth's surface area, its polar ice-caps are one and a half times as extensive. They are bright conspicuous features, remarkable for the speed at which they grow. The south polar cap may not exist at all in high summer, but in winter it spreads out over no less than four million square miles, reaching half the distance from the poles to the equator. In a European context this would mean an unbroken coating of ice and snow encroaching in the space of a few months over the whole of Britain, France, Germany and the Alps, and as far into Italy as Venice.

But in spite of its vast expanses, Martian ice is very thin, and its retreat before the Sun's warmth in spring is correspondingly rapid. Several million square miles are once again laid bare in each hemisphere and it is interesting to deduce what these emergent areas may be like.

Some of the ice is believed to trickle away as meltwater to saturate the ground in front of the ice edge, and produce a "dark fringe" of damp ground which can be seen in the telescope. What happens to this moisture—potentially so precious a commodity on an arid planet? And is there frozen groundwater resembling the "permafrost" layer of Earth's Arctic areas? In Spitzbergen the permafrost was found to extend down to 1000 feet by coal prospectors, and to remain frozen all the summer even where the surface ice completely melts away. Mars too, may well have areas of surface thaw and deeper permafrost, and any interplanetary expedition would have to be prepared for the consequences of these conditions.

The top few inches of the ground thaw and soften first, and meltwater oozes on to it. But underneath lies the iron-hard, solidly frozen impermeable layer which debars the downward percolation of moisture. The meltwater has no alternative, therefore, but to go on accumulating in the same shallow surface layer. First the ground is dampened, then drenched and saturated, until it is converted into a soggy waterlogged sludge of very unstable character. Soon it may be fluid enough to flow, and it rolls away downslope in thick turgid slow-motion eddies. Temporarily checked by the cold of the night, movement resumes the following day, and by about 2 p.m. whole hillsides can be seen migrating in a churning mass about one foot in depth.

If this process of "solifluction" operates on Mars as well as on the Earth it would interpose a barrier of untrustworthy bog between terra firma and the pioneer source of water supply in the ice cap. However, awareness of the possibility would enable adequate precautions to be taken.

A. COLEMAN.

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